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TRANSACTIONS

OF THE

AMERICAN SOCIETY OF CIVIL ENGINEERS.

Edited by the Secretary, under the Direction of the Committee on Library.

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MEETINGS.

Regular Meetings on the first and third Wednesdays of the month, at 8 P. M., as follows: 1878—April 3d and 17th, May 1st and 15th, June 5th and 19th, September 4th and 18th, October 2d and 16th.

The Board of Direction meets on the first Wednesday of the month, at 3 P. M.

Tenth Annual Convention will be held June 18th, 1878, at Boston.

Twenty-Sixth Annual Meeting, November 6th, 1878, at 10 A. M.

The rooms of the Society are open from 9 A. M. to 5 P. M., each business day, except Saturday, when they are closed at 3 P. M.

The Library and Conversation Room will also, for the present, be open every *Thursday Evening*, from 7½ to 10 P. M. Members are invited to avail themselves of the opportunities afforded on Thursday evenings, both for consultation of books and periodicals, and for conversation.

House of the Society—104 East Twentieth Street, New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

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CLVI.

(Vol. VII. March, 1878.)

ON A NEW METHOD OF DETECTING OVERSTRAIN IN IRON AND OTHER METALS, AND ON ITS APPLICATION IN THE INVESTIGATION OF THE CAUSES OF ACCIDENTS TO BRIDGES AND OTHER CONSTRUCTIONS.

A Paper by ROBERT H. THURSTON, C. E., Member of the Society.

READ MARCH 20TH, 1878.

It has been shown by the writer* and by other investigators that, when a metal is subjected to stress exceeding that required to strain it beyond its original apparent, or "primitive," elastic limit, this primitive elastic limit becomes elevated, and that strain-diagrams obtained autographically, or by carefully plotting the results of well conducted tests of such metal, are "the *loci* of the successive limits of elasticity of the metal at the successive positions of set."†

It has been shown by the writer also that, at the successive positions of set, strain being intermitted, a new elastic limit is, on renewing the application of the distorting force, found to exist at a point which

* See Trans. Am. Soc. C. E., 1874, *et seq.*, Journal Franklin Institute, 1874; Van Nostrand's Eclectic Engineering Magazine, 1874, etc., etc.

† On the strength, etc., of Materials of Construction. 1874, Sec. 20.

approximately measures the magnitude of the load at the moment of intermission.*

It has been still further shown by the writer, and by Commander Beardslee, U. S. N., by direct experiment in the Mechanical Laboratory of the Stevens Institute of Technology, and at the Washington Navy Yard, that the normal elastic limit, as exhibited on strain-diagrams of tests conducted without intermission of stress, is exalted or depressed when intermission of distortion occurs, according as the metal belongs to the iron or to the tin class.† This elevation of the normal elastic limit by intermitting strain is, as has been shown, variable in amount with different materials of the iron class and the rate at which this exaltation progresses is also variable. With the same material and under the same conditions of manufacture and of subsequent treatment, the rate of exaltation is quite definite and may be expressed by a very simple formula. The writer has experimented with bridge material, and Commander Beardslee has examined metal specially adapted for use in chain cables, for which latter purpose an iron is required, as in bridge building, to be tough as well as strong and uniform in structure and composition. The experiments of the latter investigator have extended to a wider range than have those of the writer, and the effect of the intermission of strains considerably exceeding the primitive elastic limit has been determined by him for periods of from one minute to one year.‡ From a study of the results of such researches and from a comparison with the latter investigation, which was found to be confirmatory of the deduction, the writer has found that, with such iron as is here described, the process of exaltation of the normal elastic limit due to any given degree of strain usually nearly reaches a maximum in the course of a few days of rest after strain, its progress being rapid at first and the rate of increase quickly diminishing with time. For good bridge irons, the amount of the excess of the exalted limit, as shown by subsequent test, above the stress at which the load had been previously removed may be expressed approximately by the formula :

$$E^1 = 5 \text{ Log. } T + 1.50 \text{ per cent.};$$

in which the time, T, is given in hours of rest after removal of the tensile stress which produced the noted stretch.

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* On the Mechanical Treatment of Metals ; Metallurgical Review, 1877 ; Engineering and Mining Journal, 1877.

† Trans. Am. Soc. C. E., 1877.

‡ The result on this investigation is completed and will be presented to the President of the United States by the United States Board appointed to test iron, steel, etc.

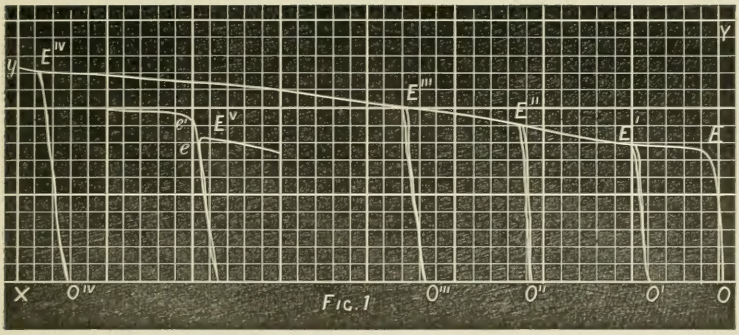

FIG. 1

Thus, in the figure, which is a facsimile of a part of a strain-diagram produced by such an iron, during a test in which the intermission of stress was of too brief duration to cause an observable exaltation of the normal elastic limit in a diagram drawn on so small a scale, the point E is the primitive elastic limit of the material, and E^{I} E^{II} E^{III} E^{IV}, are the normal elastic limits corresponding to sets under loads which have strained it beyond that primitive elastic limit. In the example here illustrated, the primitive limit is found at about 20,000 pounds per square inch, or 1,400 kilograms per square centimeter, and the other points are those corresponding to loads of, respectively, 21,000, 22,500, 25,000 and 30,000 pounds on the inch, or to 1 470, 1 575, 1 750 and 2 100 kilograms on the square centimeter. The corresponding extensions, as shown on the diagram, are 1.25, 2.53, 4.50 and 6.78 per cent.

Had the stress been intermitted at either of these points any considerable period of time, there would have been observed a rise in the diagram as above stated like that shown in Fig. 1, at E^{V} the normal elastic limit e, being, on subsequent test, found altered and a new limit, e', observed. The extent of this elevation of the limit would be the greater as the time of rest was greater, as already seen.

Thus, it is seen that a metal, once overstrained, carries, permanently, unmistakable evidence of the fact* and can be made to reveal the amount of such overstrain at any later time with a fair degree of accuracy. This evidence cannot be entirely destroyed, even by a moderate degree of annealing. Often, only annealing from a high heat, or reheating and reworking, can remove it absolutely. Thus, too, a structure, broken

* The writer has found by subsequent tests, that transverse strain produces the same effect upon the elastic limit for tension.

down by causes producing overstrain in its tension members, or in its transversely loaded beams (and, probably, in compression members—although the writer is not yet fully assured of the latter), retains in every piece a register of the maximum load to which that piece has ever been subjected ; and the strain-sheet of the structure, as strained at the instant of breaking down, can be thus laid down with a fair degree of certainty.

Here, then, when the work above detailed shall have been properly complemented with experimental determinations of the behavior of all the materials of general use in construction, may be found a means of tracing the overstrains which have resulted in the destruction or the injury of any iron or steel structure, and of ascertaining the cause and the method of its failure, in cases frequently happening in which they are indeterminable by any of the usual methods of investigation.

The fact of the normal variation of the elastic limit, as change of form progresses under gradually increased load, has been well established by the experiments of Hodgkinson, Clark, Mallett, and other English investigators ; by Tresca, particularly, in France ; by Werder and Bauschinger in Germany, and by Beardslee, the writer and others in the United States.

The exaltation of the series of normal limits so produced, still further, as shown by the writer and as seen in Fig. 1, by the intermission of strain, as at E^{v}, is also a matter of no uncertainty as to its character, although much more study is needed to determine the modifying effects of time of intermission on metals of the two great classes and of differing composition. The method above outlined of determining the extent of previous overstrain may therefore be expected to have many useful applications.

In illustration of an application of the facts thus reviewed to the determination of the causes and the method of the injury or the destruction of a structure, assume the existence of a set of conditions which is familiar to, probably, every engineer in the country who has seen much of the Howe truss, and of some other forms of bridges, as frequently built before the present generation of professional bridge builders effected a revolution in that department of engineering construction.

Suppose one of these bridges to have been built with a span of 150 feet and to have been given such proportions that, with a weight of 1,200 pounds per running foot and a load of one ton per running foot, the maximum stress on end-rods, or other members most strained, is as high

as 20 000 pounds per square inch of section of metal. Suppose this bridge to have its tension members composed of a fair, but unrefined, iron, having an elastic limit at about 17 000 pounds per inch, and a tenacity of 45 000 to 48 000 pounds, and with an extensibility of about 20 per cent.

Suppose this structure to break down under a load exceeding that usually sustained in ordinary work, and the cause of the disaster to be "involved in mystery."

Suppose portions of the several tension members to be subsequently removed, and, a few days after the accident, to be carefully tested, with the following results :

	Elastic Limit.	Tenacity.
Sample No. 1	16 500	46 000
" " 2	18 000	48 000
" " 3	30 000	48 000
" " 4	22 500	50 000
" " 5	25 000	52 000
" " 6	27 500	52 000
" " 7	28 000	52 000
" " 8	30 000	52 000
" " 9	32 000	53 000
" " 10	34 000	53 000

And that the extensibility is found to be as little as from ten to fifteen per cent.

Suppose it to be found that the tension members were straight bolts without upset ends, the threads being cut, as was once common, in such a manner that the section at the bottom of the thread is one-third less than the sectional area of the body of the bar. Suppose, finally, that the location of the tested pieces in the structure being noted, it is found that the stronger metal, having also the highest elastic limit, came from the neighborhood of the point at which the bridge gave way, and that the weakest metal and that exhibiting the lowest elastic limit came usually from points more or less remote from the break. It is not likely that in all cases the increase in the altitude of the elastic limit and the increase noted in the ultimate strength of the samples would exhibit a regular order coincident with the order of the rods as to position in the structure ; since the magnitude and the arrangement of the bars would, to a certain extent, determine the relative amounts of strain thrown upon them by overloading any one part of the truss. For present purposes we may assume the order of arrangement to be thus coincident.

On examination of the figures as above given, the engineer would conclude : First, that the original apparent elastic limit of the iron used

in this case must have been not far from 17 000 pounds per square inch and that its tenacity was between 46 000 and 48 000 pounds; secondly, that this primitive elastic limit had been elevated, by subsequent loads exceeding that amount, to the higher figures given by the bars numbered from 3 to 10 inclusive; thirdly, that the ultimate strength of the material had been, in some examples given above, increased by similarly intermitted strain.

It would be concluded that the ordinary loads, such as had been carried previously to the entrance upon the bridge of that which caused its destruction, never exceeded, in their straining action, 16 500 pounds per square inch of section of tension rod at the part of the truss from which No. 1 had been taken, and that the other rods tested had carried, probably, at the time of the accident, loads approximately equal to those required to strain them to the extent measured by their elastic limits at the time of testing them.

It would be concluded that the rod from which No. 10 was cut was either that most strained by the load, and therefore nearest the point of fracture of the truss, or that it was very near that point, and it would be made the basis of comparison in further studying the case.

As this elastic limit approaches most nearly the breaking strength of the metal, we may apply the formula for the elevation of the elastic limit with time after intermitted strain which has been above given as derived from tests of a metal of very similar quality. Taking the time of intermission as one week, the extent of the increase has a probable value not far from $E' = 5 \log. 168 + 1.5 =$ nearly $12\frac{1}{2}$ per cent. The magnitude of the stress upon this piece at the time of the accident was therefore 34 000 less one-ninth of that value, or about 30 000 pounds per square inch of cross-section of the bar. This corresponds to about 45 000 pounds per square inch at the bottom of the thread, and is within five per cent. of the primitive breaking strength of the iron. The bar, if broken at the screwed portion, has therefore yielded either under a dead load which was at least equal to its maximum resistance, or under a smaller load acting so suddenly as to have the effect of a real "live load." Or the slight difference here noted may be due to a flaw at the point of fracture. However that may be, it is almost certain that the body of the rod has sustained a stress of not far from 30 000 pounds per square inch.

But it is found, on further investigation, that the load on the structure at the time of the accident was but sufficient to make the maximum

stress on these rods—if properly distributed—20 000 pounds per square inch at the threaded part of the piece ; which piece, it has been seen, has been broken by a strain nearly double that figure. The fact is at once inferable that the load came upon these members with such suddenness as to have at least the effect of a live load (as taken in the text-books) and giving a maximum stress equal to twice that produced by the same load gradually applied, *i. e.*, the case in which the load falls, through a height equal to the extension of the piece strained by it, the resistances being assumed to increase directly as the extension up to the point of rupture, —an assumption which is approximately correct for brittle materials like hard cast iron, but quite erroneous in the case of some ductile materials, which latter sometimes give a "work of ultimate resistance" amounting to three-fourths or even five-sixths of the product of maximum resistance by the extension.

This accident was therefore caused by the entrance upon the bridge of a load capable of straining the metal to about one-half of its ultimate strength, if slowly applied, but which, in consequence of its sudden application, doubled that stress.

This sudden action may have been a consequence either of its coming upon the structure at a very high speed, or a result of the loosening of a nut, or of the breaking of a part of either the bridge floor or of one of the trucks of the train. The latter occurrence, permitting the load to fall even a very small distance, would be sufficient.

This paper is not presented as a perfectly satisfactory statement of definite facts from which absolutely reliable conclusions can be drawn. The whole subject is deserving, however, of very careful and very extended experimental investigation, and the writer has been able to obtain but a small amount of satisfactory definite information in regard to it as yet. The figures given do not exactly represent those obtained from any actual case. They do, however, fairly illustrate the limited experience of the writer, and are nearly exact for at least one case ; they may serve to indicate the possible value of the cautious application of the method here outlined of studying the causes of such accidents as are considered in the hypothetical case here taken.

The same method may sometimes be used to ascertain the probable cause of a boiler explosion by determining whether the metal has been subjected to overstrain in consequence of overpressure. The causes of accidents to machinery may also be thus detected, and many other applications will suggest themselves to every engineer.

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CLVII.

(Vol. VII.—March, 1878.)

STEAM ENGINE ECONOMY.

A UNIFORM BASIS FOR COMPARISON.

A Paper by CHARLES E. EMERY, M. E., Member of the Society.

In writing a general report on the exhibits referred to the judges of Group XX, Centennial Exhibition, the writer compared the facts available in regard to the economy of steam-engines of various kinds on the uniform basis that the boiler is capable of absorbing 10 000 heat-units per pound of coal consumed. This corresponds to an evaporation of 8.99 pounds of water at 80 pounds pressure, 9.03 pounds at 60 pounds pressure, or, 9.08 pounds at 40 pounds pressure from a temperature of 100° in each case. This evaporation is higher than is usually obtained, but has been so much exceeded in practice* that it is not considered too high for a basis of comparison. The basis, moreover, enables the duty of pumping-engines and other steam machinery to be ascertained and expressed in a very ready and convenient manner. Ten thousand heat-units per pound of coal is equivalent to one million heat-units per 100 pounds of coal, and as the duty of pumping-engines is conventionally expressed in millions of foot-pounds per 100 pounds of coal, it follows on the basis presented that *the number of foot-pounds per heat-unit*

* See examples at page 75 of the report referred to.

represents also the number of millions of foot-pounds duty per 100 *pounds of coal.* The performance of all kinds of steam-engines may be readily compared on this basis. The simplest application is in testing vacuum-pumps, the duty of which may be readily ascertained by noting the height of lift, and the initial and final temperatures of the water lifted. All the heat of the steam not expended in work enters the water, and the work performed lifts the same water. The difference in temperature gives very nearly the number of heat-units imparted to each pound of water lifted, and each pound of water so heated is lifted a certain number of feet high, so the result may be expressed readily in foot-pounds per heat-unit, which, as before stated, equals also, on the basis presented, the number of millions of foot-pounds duty per 100 pounds of coal. For ordinary comparisons the number of millions duty equals the lift divided by the difference between the initial and final temperatures of the water. For more accurate computations, the divisor should be increased by the number of heat-units expended for work per pound of water lifted, which equals the height divided by 772. The height preferably should be calculated from the indications of a pressure-gauge at the bottom of the discharge-pipe, so as to include frictional resistances. If D = duty in foot-pounds per 100 pounds of coal, H = the height of lift per gauge, and t and T = the initial and final temperatures respectively, then

$$D = \frac{1\,000\,000\ H}{T - t + .0013\ H}.$$

Arrangements have been made by the writer to use the same basis in testing pumping-engines, by discharging water from the hot well into the suction of the main pumps, and noting with delicate thermometers the resulting increase of temperature of the water lifted.

A vacuum-pump tested by the writer in 1871 gave a duty, on the above basis, of $4\frac{7}{10}$ millions; one tested by Mr. J. F. Flagg at the Cincinnati Exhibition in 1875, reduced to the same basis, gave a maximum duty of $3\frac{2}{10}\frac{7}{0}$ millions. Several vacuum and steam-pumps tested on this basis at the suggestion of the writer about two years since, gave duties reported as high as 10 000 000 to 11 000 000, the very small steam-pumps doing no better apparently than the vacuum-pumps, which is by no means surprising. Elaborate experiments made with steam-pumps at the American Institute Exhibition of 1867,* showed that average-sized

* See report of Messrs. Holmes, Selden, and Emery, judges, &c., Transactions American Institute, 1867–68.

steam-pumps do not, on the average, utilize more than 50 per cent. of the indicated power in the steam-cylinders, the remainder being absorbed in the friction of the engine, but more particularly in the passage of the water through the pump. Again, all ordinary steam-pumps for miscellaneous uses require that the steam-cylinder shall have 3 to 4 times the area of the water-cylinder to give sufficient power when the steam is accidentally low; hence, as such pumps usually work against the atmospheric pressure, the net or effective pressure forms a small percentage of the total pressure, which, with the large extent of radiating surface exposed and the total absence of expansion, makes the expenditure of steam very large. One pump tested by the writer required 120 pounds weight of steam per indicated horse-power per hour, and it is believed that the cost will rarely fall below 60 pounds; and as only 50 per cent. of the indicated power is utilized, it may be safely stated that ordinary steam-pumps rarely require less than 120 pounds of steam per hour for each horse-power utilized in raising water, equivalent to a duty of only 15 000 000 foot-pounds per 100 pounds of coal on the same basis adopted for the vacuum-pumps. With larger steam-pumps, particularly when they are proportioned for the work to be done, the duty will be materially increased.

Ten thousand heat-units per pound of coal represents an ultimate efficiency of only (10 000 × 100 ÷ 14 500 =) 69 per cent. of the calorific value of anthracite coal, so that ordinarily more than (100 — 69 =) 31 per cent. of the heat in the fuel is carried to waste up the chimney. A still greater loss is, however, experienced in utilizing the steam for the purpose of work in the engine. The mechanical equivalent of one heat-unit is 772 foot-pounds, which, on the basis referred to above, corresponds to a duty of 772 millions of foot-pounds per 100 pounds of coal. The most economical steam engines, for instance, pumping-engines of approved types, utilize in the steam-cylinder only about 130 millions, on the same basis, equivalent to an ultimate efficiency of (130 × 100 ÷ 772 =) 16.84 per cent. of the heat in the steam, and but (16.84 × .69 =) 11.62 per cent. of the calorific value of the fuel. The principal reason for this is that the exhaust steam necessarily carries to waste the heat required to maintain it in a vaporous state at the tension due to the back pressure. This under the most favorable circumstances forms the larger proportion of the total heat of the steam and reduces the opportunities for securing economy within small limits compared with the theo-

retical limit, although the differences between the performances of different engines are great when compared one with another.*

Means for securing economy in steam-engines may be divided into two classes, viz., those of a mechanical nature and those which influence the thermal conditions. As to the first, the necessity of securing tight pistons and valves, ample area of cylinder passages, reduced clearances, etc., are well understood, also the incidental advantages due to a certain degree of compression. Those of the second class act to reduce the cylinder condensation, and include high speeds of revolution, steam superheating, steam-jacketing, and the compounding of engines. High speed of revolution (which does not necessarily imply high piston speed, as generally understood) secures economy, by reducing the time in which the transfers of heat to and from the steam and inclosing walls must take place.†

Superheating the steam has experimentally proved effective for moderate rates of expansion, in which the original temperature required to maintain the gaseous condition of the steam to the point of release was not too high to prevent proper lubrication. Mr. Geo. P. Dixwell, of Boston, Massachusetts, has applied a thermometer to a steam-cylinder, by inspection of which it is possible to regulate the temperature so as to prevent injury to the metal surfaces. The great difficulty is, however, to secure a permanent and reliable superheating apparatus. Steam-jacketing has to a limited extent advantages of the same kind as superheating, and involves no serious difficulties in management. The jackets are most effective on long cylinders of small diameter. In experiments with

* In view of discussions in progress at the date of writing on the proper details of a theoretically perfect steam-engine, it is proper to mention that in the year 1868 the writer designed and partially constructed a non-exhausting experimental engine in which the steam, after expansion in the cylinder, was to be circulated through another vessel, to withdraw the water due to the performance of work; the dry steam was then to be returned to the cylinder and compressed, which it was expected would require less power than the expansion would furnish, and sufficient steam only be received from the boiler to supply that condensed for work. A demonstration of the correctness of the principle only was intended, the power expected being so small that the experimental engine was to be connected to another to keep it in motion. Before the apparatus was completed the funds were diverted to objects of greater immediate necessity, and the subject is mentioned only as indicating the general principle upon which a theoretically perfect steam-engine may be constructed. See description of the apparatus in article on the "Theoretical Steam-Engine," *Scientific American* Supplement, August 18, 1877. See also Prof. Thurston's calculations on a similar subject in *Journal of the Franklin Institute*, October, November and December, 1877.

† The value of this saving was determined by the writer for the Novelty Iron Works, Mr. Horatio Allen, President, in the year 1868, and embodied in a series of tables showing the relative power and economy of different sizes of steam-engines, which tables were afterwards published by Prof. W. P. Trowbridge, the former Vice-President of the company.

United States revenue steamers, hereinafter mentioned, the economy of a steam-jacket on a comparatively short cylinder was found to be 11 to 12 per cent.

Compound engines, in addition to advantages of a mechanical nature, in better distributing the strains and rendering more uniform the rotative efforts, serve also to reduce cylinder condensation by the distribution of the differences of temperature between two cylinders. The radiation to and from the steam and its inclosing walls increases more rapidly than the difference in temperature, so that the aggregate loss, when the difference of temperature is divided between two cylinders, is less than when it all occurs in a single cylinder.* Moreover, the heat imparted to the exhaust steam by the metal of the first cylinder is available for work in the second, and the low-pressure piston acts as a screen between the high temperature in the small cylinder and the low temperature in the condenser.

It is still strenuously denied by many that greater economy can be secured with a compound engine than with a long-stroke single engine, using the same steam pressure. There are coasting steamers of similar size running regularly in the United States using both types of engine, with, it is claimed, substantially the same results; but the boilers for the single engines are evidently the more economical, making an accurate comparison impossible. Strictly comparative experiments have, however, been made by Chief Engineer C. H. Loring, U. S. N., and the writer with engines of different kinds in the steamers of the United States Revenue Marine, and by the writer with some of those of the United States Coast Survey.†

The revenue steamers were of the same size and the boilers very nearly identical. In one steamer was a compound engine with steam-jacketed cylinders; in another, a long-stroke, high-pressure condensing engine (cylinder not jacketed); in another an ordinary low-pressure engine (cylinder not jacketed); and in still another, a high-pressure condensing engine with a jacketed cylinder. The compound engine showed a saving of 12 to 16 per cent. compared with the best performance of either single

* See article by the writer in *American Artizan*, March 8, 1871.

† See article by the writer on "Compound and Non-Compound Engines." *Transactions American Society of Civil Engineers*, vol. iii, p. 68, 1875: *Journal of the Franklin Institute*, February and March, 1875; *Engineering* (London), January, February and March, 1875; *Proceedings of Institution of Civil Engineers* (British), vol. xl., p. 292, and vol. xli, p. 296; also Report of trial of United States Revenue steamer *Gallatin*, *Journal of the Franklin Institute*, February, 1876, and vol. xxi., *Engineering*, 1876.

engine when operated at the same steam pressure. It is believed that substantially the same differences will be found in all cases when equally good engines of both types are compared. The performance of a short-stroke compound engine may be equalled or even excelled by that of a long-stroke single engine, on account simply of the difference in clearance spaces and the superior efficiency of the steam-jacket in the latter case, but by making the compound cylinders in the same form they should still show an advantage. In practice, the economy of marine compound engines is greater than above mentioned, for the reason that the high steam pressure is better maintained with them by the engineers than when single cylinders are used with high rates of expansion, causing difficulties in management.

The following table shows, in line 1 the performance of one of the Leavitt compound beam pumping-engines, at Lawrence, Massachusetts, and in line 2 that of the engines of the *Rush*, one of the revenue steamers previously referred to :

	Approximate Steam Pressure.	Ratio of Expansion.	Diameter of Small Cylinder.	Diameter of Large Cylinder.	Strokes of Pistons.	Revolutions per Minute.	Piston Speed.	Mean Pressure Referred to Large Cylinder.	Indicated Horse-Power.	Water per indicated Horse-Power per Hour.
			Inches.	Inches.	Inches.		Feet per Minute.	Pounds.		Pounds.
1	90	13.05	18	38	96	16.27	260.3	22.15	196.4	14.02
2	70	6.22	24	38	27	70.84	318.8	24.48	266.6	18.38

The comparison is very interesting. In both engines the larger cylinders are of the same diameter, but the difference in the duty for which the engines were designed required great differences in other proportions and in all the details of construction. In the pumping-engine for use on land there were no restrictions as to weight and space, so a comparatively long stroke could be employed and the connections made through a beam. The marine engine had, however, to be located in a small vessel, and was therefore directly connected and proportioned accordingly. Yet the long-stroke engine was run with so much expansion and at so slow a speed as to develop less power than the smaller one, and the latter was less economical, on account of the lower steam pressure and rate of

expansion and the relatively greater proportion of waste room in the cylinder, incident to the necessary use of ordinary slide-valves. The engine of the *Rush* was, however, more economical than the ordinary stationary compound engines used for manufacturing purposes, as the latter, according to published reports in the engineering journals, require the evaporation of not less than 20 pounds of water for each indicated horse-power. The Lawrence engine contains all well known means for securing maximum economy of steam, and it is probable that few if any engines are working with greater economy in respect to the indicated power. The performance is, however, much below that given by calculation when all the conditions are taken into consideration, other than the slight distortion of the theoretical indicator diagram found in practice and the important loss due to cylinder condensation.

In an engine using a total pressure of (90 + 14.7 =) 104.7 pounds, expanded 13.5 times in a cylinder, with clearances, etc., equal to .02 of the displacement, the calculated cost of one horse-power per hour, or 1 980-000 foot-pounds, should be only 8.12 pounds of water evaporated from the initial pressure, on the basis that the curve of expansion is hyperbolic, and that the consumption of steam equals the volume at the initial pressure, required to fill the cylinder to the point of suppression, plus that condensed for the total work. With a pressure of 100 pounds above the atmosphere, and an expansion of 20 times, there should be required on same basis the evaporation of only 6.00 pounds of water per indicated horse-power per hour. It is probable that the practical results obtained with the latter pressure and expansion would be little or no better than those from the Lawrence engine, on account of the greater cylinder condensation due to the increased expansion.

The above calculated performances, and the practical results obtained with engines and other steam machinery of various kinds, is shown in the accompanying table, in connection with the relative efficiencies obtained by considering the heat-units in the steam and the calorific value of the fuel. The table and a portion of the above are from the report previously mentioned, and the references are to pages therein.

Number of Line for Reference.	1 Description.	2 Steam Pressure.	3 Ratio of Expansion.	4 Water evaporated per indicated Horse-Power per Hour.	5 Comparative Results on Basis that 10,000 Heat-Units are imparted to Water per Pound of Coal. See pages 21 and 115.** Calculations based on a Temperature of Feed of 100°. Duty in Millions of Foot-Pounds, per Indicator, per 100 Pounds of Coal. Pages 21 and 115.**	6 Relative Efficiency, based on the Proportion utilized of the total Heat of the Steam.	7 Relative Efficiency, based on the Proportion utilized of the Calorific Value of Anthracite Coal.	8 Net Effective Duty for lifting Water, in Millions of Foot-Pounds, per 100 Pounds of Coal.
1	Calculated performance. Maximum	.....	.....	.....	772.0	1.00	.69	
2	Calculated performance (see page 120)**	100	20	6.005	295.2	.382	.264	
3	Calculated performance	90	13.5	8.122	218.6	.283	.195	
4	Lawrence compound beam pumping-engines	89.4	13.7	14.019	126.7	.164	.113	
5	U. S. Revenue steamer Rush,* compound engine	69.2	6.22	18.384	97.03	.126	.087	
6	U. S. Revenue steamer Gallatin,* vertical cylinder with steam-jacket	67.2	4.19	21.48	83.08	.108	.074	
7	U. S. Revenue steamer Dexter,* vertical cylinder without steam-jacket	67.1	3.49	23.905	74.66	.097	.067	
8	U. S. Revenue steamer Dallas,* vertical cylinder without steam-jacket	32.0	3.13	26.945	66.91	.087	.060	
9	U. S. steamer Mackinaw,† inclined cylinder without jacket	49.0	2.2	30.306	59.16	.077	.053	
10	U. S. steamer Mackinaw, steam superheated	52.0	3.2	22.725	78.83	.102	.070	
11	Non-condensing engine, with governor cut off,‡ (st. jacket)	81.7	5.0	25.482	69.81	.090	.062	
12	Non-condensing engines, regulated by throttle	.....	.....	.....	30 to 45	.04 to .06	.03 to .04	
13	Pumping-engines							30 to 110
14	Steam-pumps. Large size proportioned for the work to be done							15 to 30
15	Steam-pumps. Small sizes for ordinary uses. See page 22**							8 to 15
16	Vacuum-pumps. See page 21,** also page 61 herein							3 to 10
17	Injectors when used for lifting water not required to be heated. See page 96**							2 to 5

* See references in foot-note, page 119,** also†, page 64 herein.
† See vol. ii. Isherwood's *Experimental Researches in Steam Engineering*, pp. 77–116.
‡ *American Institute Reports*, 1869–70, 1870–71.
** General Report of the Judges of Group XX, Philadelphia Int. Exhibition. Lippincott & Co., Philadelphia.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—The Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

CLVIII.

(Vol. VII.—March, 1878.)

THE INCLINE PLANE RAILROAD AT MADISON, IND.

ITS HISTORY AND OPERATION.

By M. J. BECKER, C.E., Member of the Society.

The history of the Incline Plane Railroad at Madison, Indiana, the changes in the methods of its operation, and the information which may be drawn from the experience of its working during a period of more than thirty years seem to present matter of considerable interest to engineers. I have been able to secure the following account, which has been mainly collected by Mr. R. Wells, Master Mechanic of the Jeffersonville, Madison and Indianapolis Railroad, and which contains all the reliable information it has been practicable to gather on the subject.

The Incline Plane at Madison was constructed under the supervision of Thomas Morris, as Chief Engineer, and was part of the main line of road between Madison and Indianapolis. The time when the Plane was first opened for traffic has not been ascertained, but business on it was carried on by using horses to draw the cars up until the fall of the year 1847.

The foot of the incline plane is 3620 feet from the depot in Madison (the terminus of the road). This track, from the depot to the foot of the incline has a grade averaging 1 in 110, and for about 800 feet next the

foot of the incline is on a curve of about 1000 feet radius. The incline is 7040 feet long, and the grade averages 1 in 17, but for about half the distance is 1 in 16.5, and at two places is a little heavier than that from the settling of the embankment. The track was originally straight, but owing to the sliding of the embankment at a point near the centre of the incline, it was slightly curved at that place. The gauge of the track was originally the same as it is now, 4 feet 8½ inches. In the year 1845, M. W. Baldwin, of Philadelphia, built a locomotive called the De Witt Clinton, having six coupled driving wheels 42 inches in diameter and cylinders 13 × 20 inches, for working this incline; but as the engine could draw but two cars up at a time, depending on its weight on the rails for adhesion, it did not prove satisfactory, and as stated before, horses were used to draw the cars up the incline until the year 1847. About the year 1845, an old gentleman named Hoyt, who lived near Dupont, on the line of the road, fourteen miles from Madison, conceived the idea of laying a cast iron rack on the outside of the rails of the track, and level with the top of the rails, to be laid on steep inclines such as this, and a wheel, or segments with cogs corresponding to those in the rack was to be attached to the outside of one of the driving wheels so that when the locomotive came to the part of the line where the rack was laid, the cogs on the one would work into those of the other, preventing slippage, the tire of the wheel at the same time carrying its weight the same as other places. To obtain the requisite power to ascend inclines, Hoyt proposed to have a pinion wheel arranged so as to gear into the wheel attached to the driving wheel, driving the pinion by a cylinder and crank which, when not needed, was to be thrown out of gear. Hoyt had a rough model of his plan and explained it to the officials of the road in the various interviews he had with them from time to time, and among others, to Mr. A. Cathcart, who had charge of the machinery of the road at that time. It seems that Hoyt's plan was not considered practicable, and he met with but little encouragement, but Cathcart, soon after, perfected his own plan which he carried out and put in practice in the fall of the year 1847. He evidently was indebted to Hoyt for the original plan. Yet he used but little of Hoyt's plan, except a rack and a wheel to work in it. As a settlement for any claims that Hoyt might have to any part of Cathcart's arrangement, the latter paid the former $1000 to relinquish all claims he might have in the invention used.

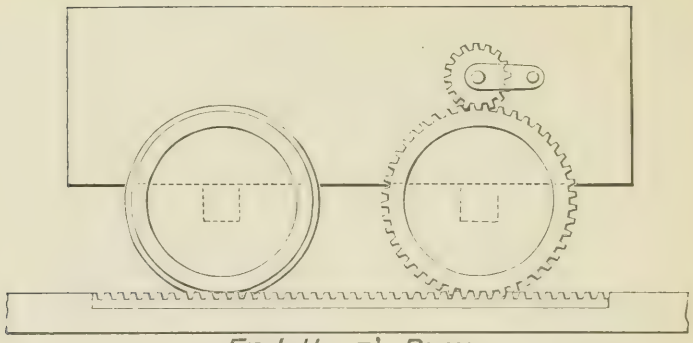

FIG. 1. HOYT'S PLAN.

Hoyt's plan is represented in Fig. 1. It is a copy of his original sketch.

Cathcart's plan is represented in Fig. 2. His locomotive had eight driving wheels coupled in the usual manner, 42 inches in diameter, and a pair of inclined cylinders 16 inches diameter and 20 inches stroke attached to the side of the smoke box, as shown in the sketch. In addition to this the engine had a pair of vertical cylinders 15 inches diameter and 18 inches stroke, shown at *B*, Fig 2. These cylinders were attached to a shaft held in place by a frame connected with the vertical cylinders, and also the frame of the locomotive. On the centre of this shaft was a pinion 16 inches in diameter, shown at *C*, gearing into another pinion shown at *D*, which, when in use, geared into the rack laid in the centre of the track as shown at *E* and *F*, Fig. 2. This pinion, *D*, was 32 inches in diameter, and was movable vertically in curved jaws, the radius of this curvature being the distance from the centre of the pinion *C* to that of the pinion *D*. For the purpose of raising the pinion *D* out of the rack when not in use, and also for holding it down in place to prevent it from slipping out of gear while at work, a cylinder of 8 inches in diameter and 12 inches stroke, shown at *G*, Fig. 2, was used by means of an L crank and suitable rods and connections, the force of the steam on one side of the piston holding the pinion down in place, and when changed to the other side raising it up out of gear where it was held by a pawl until it was to be lowered again for use. The cogs were 4 inches pitch and 8 inches face on the rack, and 8 inches face on the pinion wheel. The top of the cogs in the rack was 6 inches above the top of the rails of the track. This rack was made in sections of about 3 feet in length. It was 8 inches wide at the bottom, where it rested on the timber, as shown

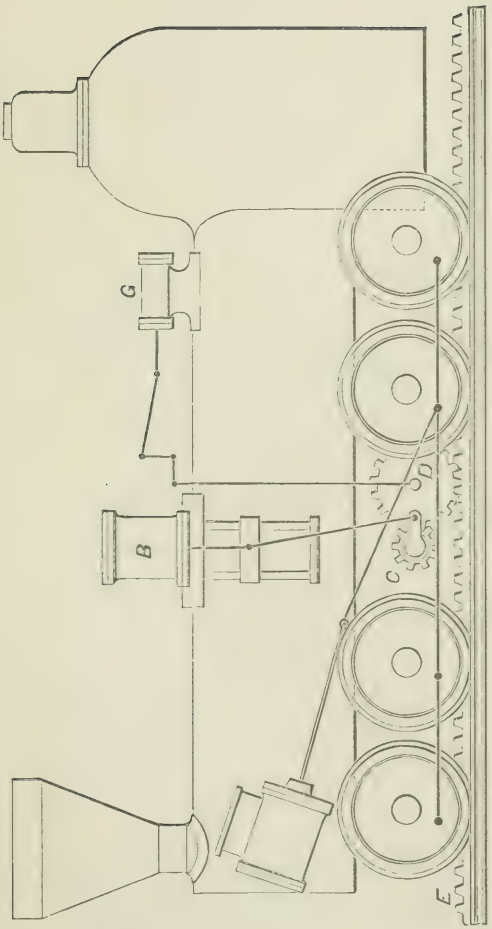

FIG. 2. CATHCART'S PLAN.

by Fig. 3, there being a flange on each side of 1 inch on which the head of the spikes rested that held the track down to the timber on which it was laid. These flanges were notched at proper intervals of ½ inch deep for the spikes, as shown at *R*, and there were also projections, *S S*, on the bottom which were let into the timber to prevent their being moved out of place. The timbers upon which the rack rested were 6 inches deep by 12 inches wide, laid on the cross-ties in the centre of the track, the ties being notched about half an inch deep to receive them, as shown in Fig. 3, at *T*. The rack was made from cold blast iron (cast). The cogs were not chilled. The pinion wheels on the locomotive were made of cold blast iron, and made in chills so as to chill the cogs to prevent wear as far as possible.

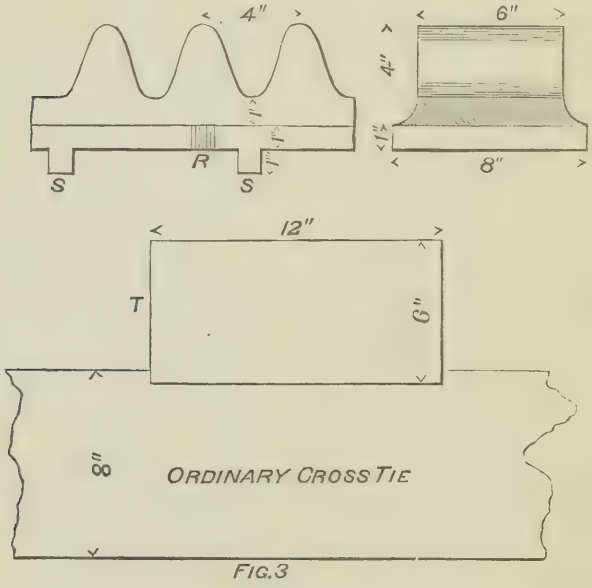

FIG. 3

This arrangement, known as Cathcart's plan, was complete and put in operation in the fall of the year 1847, and was continued in use until July, 1868, giving general satisfaction. The heavy business of the road from 1849 to 1854, and the lighter business afterwards, was all done on this plan with the two locomotives of the Cathcart plan, although the speed at which trains could be taken up and freight cars taken down was comparatively slow ; twenty minutes for passenger trains and twenty-

five minutes for freight trains was about the time occupied in ascending the incline of 7 000 feet with full trains, and the expense in maintenance of the rack and locomotive was heavy. The breakage of castings of the rack and the wearing out of pinion wheels of the locomotive, and cost of keeping up its complicated parts, the decay and removal of timber under the rack were all sources of trouble and expense, amounting to nearly the same whether heavy or light trains were drawn, and amounting to more than the business of the road would warrant in the last two or three years that arrangement was used. Owing to the expense of operating the incline, and the slow speed at which only it could be worked on this plan, it was determined to try the adhesion plan, by the use of very heavy and powerful locomotives, depending alone on the weight of the wheels on the rails for their adhesion. Consequently one was built in the company's shop of a pattern represented in Fig. 4, and put in service in July, 1868, since which time the Cathcart plan has been abandoned, and the plane worked entirely on the adhesion plan, which has been found to be much cheaper, quicker, and equally as safe, and more reliable. The principal dimensions of the locomotive, represented in Fig. 4, are as follows : Cylinder 20¼ inches diameter, 24 inches stroke ; driving wheels (five pairs), 42 inches diameter ; boiler, 56 inches diameter, ⅞ thick, 201 two-inch tubes 12 feet long ; fire-box, 5 feet 3 inches long, 5 feet 8 inches deep, 4 feet wide at top and 3 feet at grate, has 116 square feet fire-box heating surface, and 1 262 feet of tube surface. It is what is commonly called a tank locomotive, carrying wood (which is used for fuel) and water all on the five pairs of coupled wheels. The water is carried in two long cylinders (one on each side), shown at *H H*, connected to a centre water tank at the back, *I I*. These cylinders are flattened on the side next the boiler, as shown in the end view at *J*, but are the full circle back of the boiler. The two and the centre tank at the back end hold 1 800 gallons of water. The total weight of the locomotive, with fuel and water, is 112 000 pounds. A steam brake is situated at *K*, by which one-third of the weight of the locomotive can be made to rest on slides or runners forced down on the rails ; friction brakes are also attached to the drivers, and applied by means of a screw sufficiently powerful to hold the locomotive on the incline, but are not used in ordinary service.

All freight trains are let down the incline by the locomotive using compression in the cylinders as a means of retarding power. For in-

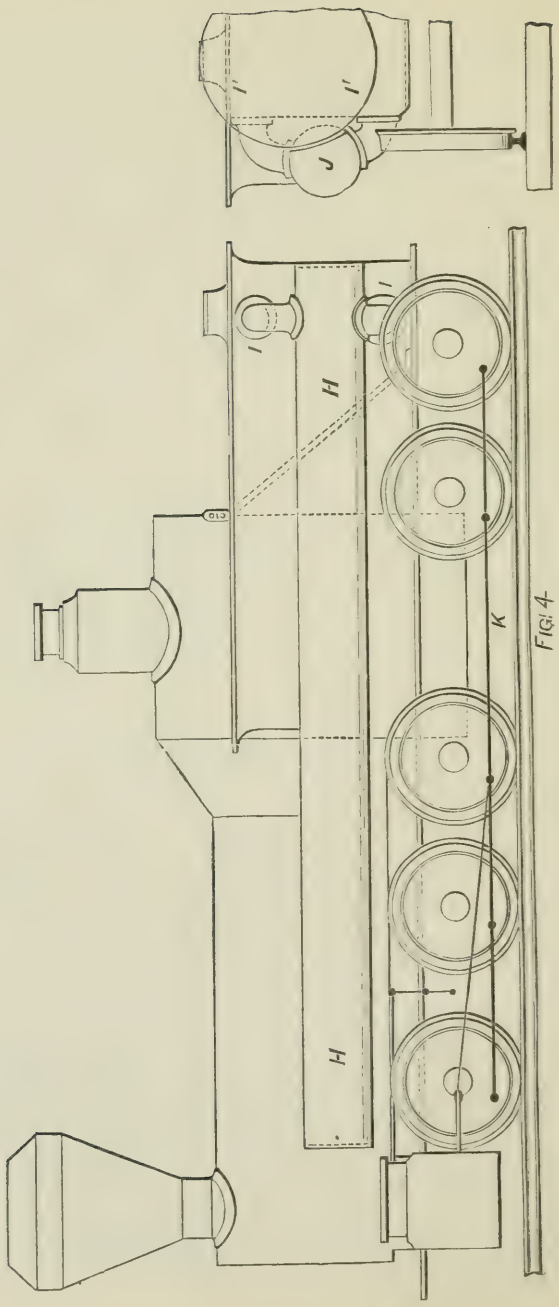

FIG. 4.

stance, when backing down the incline the valves of the cylinders are moved by the forward motion which if there was no leakage of the pistons would either force air into the boiler or cause the wheels to stop turning in that direction. But to regulate the compression so as to give the required retarding force, the two ends of the cylinders are connected by a 1-inch pipe, in which is a sliding valve closing and opening to the desired size, permitting the compressed air on that side of the piston to flow through to the opposite side of it, and being regulated for both cylinders by one lever and to any speed descending to ten miles per hour.

The loads drawn up the incline and the time required may be explained by the record of one of the number of trips made April 9th and 10th, 1875, to test the quantity of fuel used, adhesion to rails, etc. :

Trip No. 1 was made on a dry day, temperature of the atmosphere 70° Fah. The load was eight cars loaded with coal.

Weight of cars and coal	308 360 lbs.
" " locomotive	112 000 "
Total	420 360 "

Speed at foot of incline, 2 miles per hour.

Time of leaving foot of incline—

At	3.40	P. M. ;	steam pressure in boiler,		140 lbs.
"	3.45	"	"	"	140 "
"	3.50	"	"	"	143 "
"	3.52	"	"	"	140 "

Arrived at top of incline at 3.53 P. M. ; steam pressure in boiler, 130 lbs.

Distance run, 7 040 feet. Time, 13 minutes. Fuel used, $\frac{6}{10}$ of one cord of dry beech wood. No sand was used, and no slippage of the drivers occurred. The speed averaged 6 miles per hour. Trip No. 4 was made with two passenger cars, weighing 88 000 lbs. Locomotive, 112 000. Total, 200,000 lbs. Speed when going on the foot of the incline, 6 miles per hour. Time running the 7 040 feet, $5\frac{1}{2}$ minutes=$14\frac{1}{2}$ miles per hour. Steam pressure in boiler, 132 pounds. Fuel consumed, $\frac{3}{10}$ of a cord of dry beech wood. No slippage of the drivers at any time, and no sand was used. The trip was made at 7.35 in the morning. No difficulty has been experienced at any time in working this incline for want of adhesion, either in winter or summer, dry or wet weather, and this plan has proved much more satisfactory than the one previously

used, and no accident to the locomotive has ever happened while ascending or descending that in the least interfered with safety.

It may not be without interest to the parties desiring information on this subject to know that a patent was granted to one Emor Rimber, of Rimberton, Chester County, Pa., March 5th, in the year 1831, the original papers coming into my hands while making inquiry on this subject.

The paper is signed by Andrew Jackson, who was President of the United States at that time, and Martin Van Buren (afterwards President), Secretary of State.

The sketch shown at Fig. 5 will explain Rimber's plan, and is a reduced copy of the original accompanying the patent documents.

As will be seen, Rimber proposed the use of a rack and pinion in the centre of the track, carrying the driving wheels of the locomotive (one pair of them) on a pair of smaller wheels of a diameter corresponding to that of the pinion wheel in the centre. The track upon which these small wheels run was elevated sufficiently to raise the driving wheels clear of the track, permitting them to turn in conformity to the smaller wheels and the pinion wheel working in the rack, the power being applied by the cylinders and crank on the outside of the driving wheels, as when running on an ordinary track. A "drag" was proposed to follow along the rack, so as to prevent running down the grade in case of accident to the machinery in ascending the incline, as shown in the sketch. As far as I can learn, Rimber's plan was never put in operation.

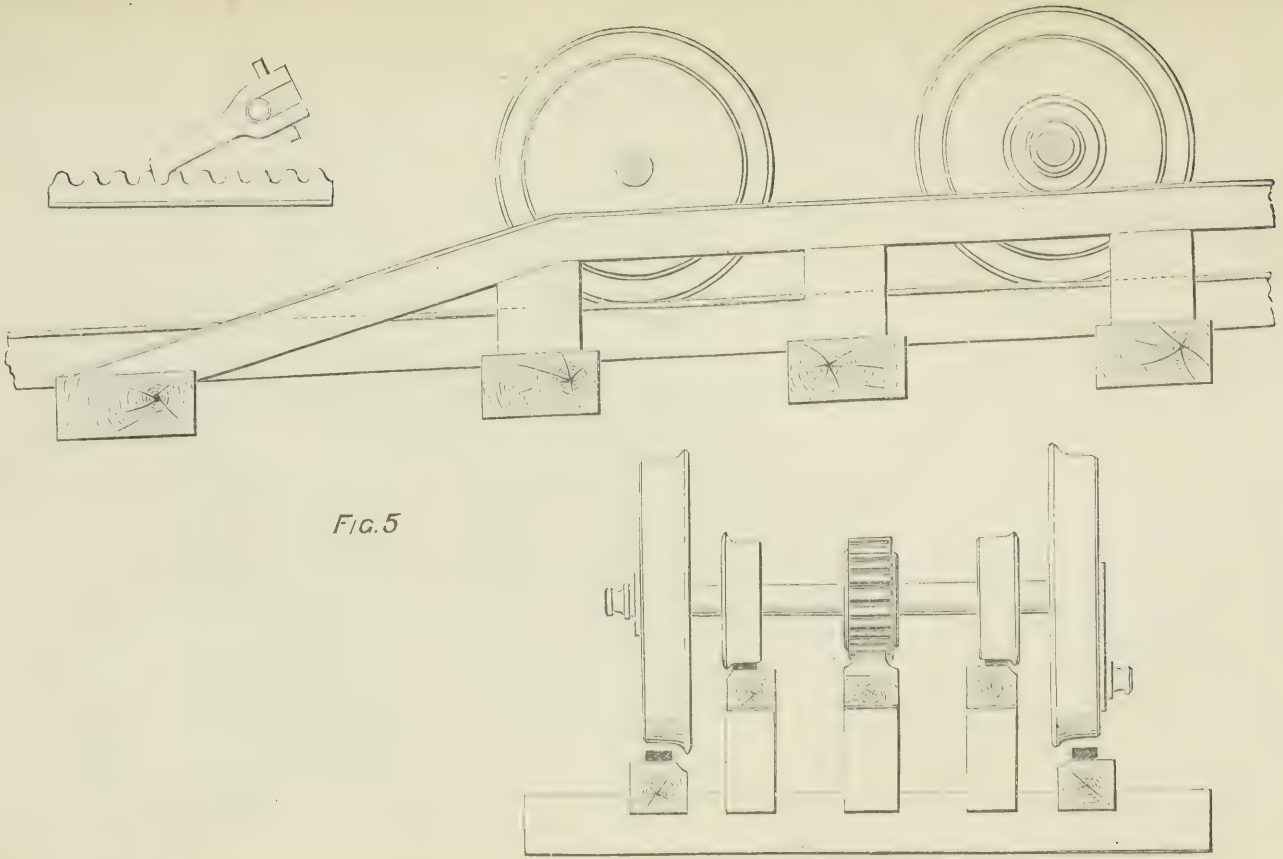

Fig. 5

American Society of Civil Engineers.

PROCEEDINGS.

Vol. IV, March, 1878.

MINUTES OF MEETINGS.

(Abstract of such as may be of general interest to members.)

OF THE SOCIETY.

APRIL 3D, 1878.—The Society met at 8 P. M., Vice-President Roberts in the Chair. The Secretary reported that there had been an attendance of members at the rooms on each Thursday evening while they had been open, and it was resolved that the Library and Conversation Room should be kept open for the present and until further action on each Thursday evening from 7½ to 10 o'clock.

Mr. E. P. North, on behalf of the Committee on Exhibit at Paris, reported progress in the collection of material for such exhibit.

The ballot upon the adoption of the following memorial was canvassed :—

To the Honorable the Senate and House of Representatives of the United States in Congress assembled :

The American Society of Civil Engineers respectfully represents to your honorable bodies, that the triangulation of the United States Coast Survey, wherever it extends, affords a convenient and accurate basis for the location of roads, railroads and public works of all kinds, as well as for topographical and other surveys ; a basis which for precision and completeness is otherwise practically unattainable.

And the said Society, according their hearty approval of the United States laws, whereby the Coast Survey Department is authorized to extend its triangulations over States where scientific surveys are ordered by the State Legislatures, respectfully petitions your honorable bodies to make the necessary appropriations for continuing such triangulations as may be called for under the said laws, whereby the valuable work of the Coast Survey may be more fully utilized, to the great advantage of all portions of the country.

Upon this there were :—

For adoption, 73 votes ; against adoption, 66 votes. The memorial was thereupon declared adopted.

On motion, it was ordered that two copies of the memorial be engrossed, signed by the President and Secretary, and forwarded, one

to the Senate and one to the House of Representatives of the United States Congress.

The ballot upon admission to membership was canvassed, and the following were declared elected :—

As Members, O. L. Glover, of Lima, Peru, and Alfred Noble, of Detroit, Mich. (elected Junior February 10, 1875) ; as Junior, Edmund Hayes of Buffalo, N. Y.

A paper by Julius H. Striedinger, entitled "The Law of Tidal Currents in River Harbors," suggested by the paper on Improvements in Boston Harbor, was read by the author, and the subject discussed by Messrs. Collingwood, Haswell, W. J. McAlpine, and Roberts.

Mr. Bogart read from advance sheet of the Transactions of the Institution of Civil Engineers an account of the plan and construction of the Hooghly floating bridge in India.

APRIL 17TH, 1878.—The Society met at 8 P. M,, Vice-President Roberts in the Chair.

A paper by M. J. Becker, entitled "The Construction, Machinery and Operation of the Incline Plane Railroad at Madison, Ind.," was read by the Secretary. The subject was discussed and illustrated by Messrs. Chanute, Forney, William J. McAlpine, Roberts, Yardley and others.

The Society then adjourned, and on invitation, through Mr. William J. McAlpine, proceeded to the rooms of Mr. Johnson, who exhibited to the Society the construction and operation of the Edison speaking phonograph.

OF THE BOARD OF DIRECTION.

APRIL 3D, 1878.—Applications for membership were considered. Appropriations were made. Questions of copyright were considered.

NOTES AND MEMORANDA.

UNITED STATES BOARD TO TEST IRON, STEEL AND OTHER METALS.—The attention of members of the Society is called to the following resolutions which were adopted at the last annual convention. The Committee of the Society upon the same subject urges upon all interested in the important work undertaken by this Board the fact that action in accordance with these resolutions must be taken at once to be of any avail. The Board must soon pass out of existence, unless further legislation is had.

Resolutions adopted at the 9th Annual Convention of the American Society of Civil Engineers :

"Whereas, in 1872, a committee of members of the American Society of Civil Engineers was appointed to take into account and to ascertain the best way of establishing a Board for the testing of such metals and alloys as form parts of the structures and machines required for use by the citizens of this country ; and

"Whereas, under this appointment, the committee proceeded in its labors so far as to obtain favorable action from the Congress of the United States, by a law authorizing the creation of a Board for the purpose of making such tests, and appropriating money to be expended therefor as well as in purchase of suitable machinery ; and

"Whereas, at a late session of Congress a law was passed, whereby said Board would cease to exist upon the expenditure of the money then appropriated; be it

"Resolved, that this Society deems the tests proposed to be made, to be of national importance, and therefore asks that so much of the Sundry Civil Appropriation Bill, passed by Congress, as provides that the Board to test iron, steel and other metals, shall be discontinued when the money appropriated for its use shall have been expended, be repealed; that the unexpended balance to the credit of the Board be re-appropriated, and that such further appropriation made be for the use of the Board as may be needed to complete the investigations undertaken—the sum required for the coming year being $40,000.

"Resolved, that each member of this Society be urged to use such influence as he may possess, to obtain favorable and immediate action by the Congress of the United States in furtherance of the objects here prayed for.

"Resolved, that the above resolutions be printed, and several copies furnished to each member of this Society, to be used by him in promoting the object sought; and that reports of their action in the matter be made by each to the Secretary, giving names of representatives in Congress who have been addressed or seen on the subject."

NOTES OF MEETINGS.

A portfolio of a number of the original drawings of the first construction of the Philadelphia & Reading Railroad was sometime since presented to the Society by Mr. MONCURE ROBINSON, Honorary Member of the Society.* Extracts from the letter of Mr. Robinson sent with the portfolio, from the pamphlets which accompanied it and from the remarks made by W. MILNOR ROBERTS, at the time of the presentation are appended.

From the letter of Mr. MONCURE ROBINSON to Vice-President Roberts:

"* * * I am gratified to learn that you and Mr. Bogart think the plans of works on the Philadelphia & Reading Railroad will be interesting to many of our members, and I will take great pleasure in forwarding them. I will enclose with them a short report made to the Board of Directors in December, 1839, after *the first trial* of the Gowan and Marx and an account by Mr. Nicolls, the superintendent of the road of her *first regular performance* in February, 1840. I will add to them an address by Professor R. E. Rogers to the Franklin Institute in 1874, in the appendix to which you will find some extracts from publications of the period contemporary with the Gowan and Marx, showing the sensation made in Europe as well as in the United States by her performance. To this was due the invitation given Messrs. Eastwick and Harrison to visit St. Petersburg to make a contract for building the locomotives and other machinery for the St. Petersburg & Moscow Railroad, a contract which Mr. Harrison has often said to me was the foundation of the large fortunes made there by himself and his copartners. * * *"

From a report, dated Philadelphia, December 10th, 1839, made to the Directors of the Philadelphia & Reading Railroad Company by Messrs. Moncure Robinson and Wirt Robinson, Engineers of the Company:

"The undersigned are gratified in being enabled to report that the line of railroad between this city and Reading was on Thursday last opened for transportation. The Company's engine, the Gowan and Marx, on that day left Reading with a train of eighty cars, conveying, with other articles,

1,635 barrels of flour,
73¼ tons of blooms,
6 tons of coal,
2 hogsheads of whiskey,
60 persons.

The weight of the train, exclusive of the engine and tender, being 368 tons and the net load conveyed 240 tons.

The failure of one of the water pipes of the engine arrested the train after the lapse of an hour, in which time it had progressed twelve miles from Reading, and made it necessary to await the arrival of another engine, the Delaware. By this engine the whole train was first pushed four miles to a sideling at Pottstown and thence drawn on twenty-four miles to Norristown.

The whole weight of the Delaware, including fuel and water is ten and a quarter tons, and of the Gowan and Marx ten and seven-tenths tons.

It is hoped that this performance of engines of lighter dimensions than those now gene-

* See Proceedings, Vol. III, page 136, December, 1877.

rally ordered for heavy transportation will satisfy such of the stockholders as have hitherto been sceptical that the results anticipated by the undersigned will be at least realized, and that the load of an engine from the coal mines to the city will not be less than the amount (150 tons) estimated in their report of September, 1838. If this be so, there can be no room for doubt that the cost of transportation estimated in that report (52¾ cents per ton), will not be exceeded. This results, on the largest estimates of the expenses of a train, as unavoidably, from the amount of the load conveyed as the latter does from the graduation of the road.

The board will now probably be better satisfied than ever that the plan of improvement they have adopted was the only proper one for the objects they had in view. If instead of a graduation, the worst case of which is a *level*, undulations not exceeding thirty feet to a mile had been admitted, the load of the engine would have been but little more than one-third of its present load, and the cost of transportation would have been increased in nearly a corresponding ratio. While the first cost of the road has been somewhat greater on the plan adopted, the cost of transportation has been reduced very nearly to its minimum. The company has thereby insured large profits on articles which can bear the customary rates of railroad transportation, and more or less profit on every article brought on their improvement, and which can be transported at all in any other way."

"The undersigned have given much attention to the description of engines most judicious for your road. Among those in general use hitherto some (the English pattern) possessed the advantage of great adhesion, but without the requisite facility in turning curves. Others with this last advantage had the weight of about half the engine only on their driving wheels, their adhesion not only being diminished in proportion, but the weight on each driving wheel being still so great as rapidly to wear out the tires of the wheels, and to produce unnecessary injury to the rails. In addition to these disadvantages in most of our engines in ordinary use, it was essential to the plan of engine for our road that it should be as well as possible adapted to the use of anthracite coal, and to slow motion. The result of the attention given by us to this subject, has so far been most satisfactory. The engine, the 'Gowan and Marx,' above mentioned as the one used on the occasion of the opening of the road for transportation, is geared for slow motion (having but three feet three inch driving wheel), and a a velocity of from eight to ten miles per hour, her draft and generation of steam with anthracite coal, appear to us as perfect as in any locomotive that we know of. With the advantage of a truck for turning curves, she has three-fourths of her weight thrown on four instead of two driving wheels, giving her thereby a large amount of adhesion, but with the weight so divided as to be but little injurious to the tire of the wheel or the road. We are not without hopes that, aided by the suggestions of her ingenious builders, Messrs. Eastwick and Harrison, of this city, and our other experienced manufacturers we may be enabled to attain the whole adhesion of the engine without giving up the guide truck, and to divide the weight equally on all the wheels of the engine; points essential to obtaining at slow velocities, the maximum useful effect of the engine, and to diminish the wear and tear, both of engines and the road. In the mean time, it will be gratifying to the Board to know that we are in possession of two plans of engine for burning anthracite coal, that of the Gowan and Marx above described, and that adopted on the Baltimore and Ohio Railroad, which will realize all that it was ever expected their road would perform, and far transcend all that was promised at its commencement, and that any farther improvements in the plan of locomotive adapted to it, will only add still further to its useful effect, and reduce still further in the wear and tear of engines and the road; adding, of course, in a corresponding ratio, to the value of the work."*

From a report made by G. N. Nicolls, Superintendent Transportation, P. and R. R. R., dated Reading, February 24th, 1840:

"Statement of the performance of the locomotive engine Gowan and Marx, built by Messrs. Eastwick and Harrison, Philadelphia, on the Philadelphia and Reading Railroad, with a train of one hundred and one loaded cars, February 20th, 1840.

"Gross weight of train, including cars and freight, but not including engine or tender, 423 tons of 2 240 lbs.

Net weight of freight, 268½ tons of 2 240 lbs.

The freight consisted of—2 002 barrels of flour, 82 do. whiskey, 459 kegs of nails, 19 tons of bar iron, 22 hhds. of meal, 5 do.

* Included in this report is an estimate for an increased supply of rolling stock, which gives as cost of locomotives $7.500 each; of coal cars $270 each, and of ordinary freight cars $250 each.

whiskey, 4 do. oil, and sundry other articles, making a total of 268 ½ tons.

Distance from Reading to the foot of the inclined plane on the Columbia Railroad 54½ miles. Running time of the engine with train, five hours thirty-three minutes; rate 9.82 miles per hour. Coal consumed, red ash, anthracite, from Schuylkill county, 5 600 lbs. Water evaporated, 2 774 gallons.

GRADES OF ROAD.

The total fall from Reading to the point where the train was stopped near the Columbia Railroad is 214.5 feet, being an average fall of 3.94 feet per mile. There is *no ascending grade* from Reading to the Columbia Railroad, with the exception of about 2 100 feet at its lower termination, graded at 26.4 feet per mile, upon which grade the train was stopped; the other grades vary from 19 to 15 feet per mile; there are only three miles graded at 18 feet and one at 19 feet per mile.

The total length of *dead level* line from Reading to the Columbia Railroad is 27 miles and 4 200 feet; of this the longest level is 9 miles and 1 500 feet long, between Norristown and the inclined plane; the others vary from 1 550 feet to 4 miles and 1 600 feet in length.

STATE OF THE TRACK.

Owing to the frost coming out of the ground at this season, the track was in worse order than at any other time of the year; this, however, did not materially affect the performance of the engine, as the embankments were all in nearly as good order as at other times; and at comparatively few points in the deep cut, was the track sufficiently out of line or level to offer increased resistance to the train.

The superstructure of the road consists of a T rail, 45 lbs. to the yard, laid upon sills 7 feet long and 7 by 8 inches square, 3 feet 1½ inches apart from centre to centre, and laid on broken stone.

STATE OF THE RAILS.

For the first twenty miles the rails were in very bad order, the morning was cloudy, and a fog of the previous night had left sufficient moisture on the surface of the rails to diminish considerably the adhesion of the engine; for the remainder of the distance the weather was clear and the rails in good order.

WORKING OF THE ENGINE.

On three different occasions the engine started the whole train on a dead level, and when on a dry rail, without the wheels slipping.

The steam ranged from 80 lbs. to 130 lbs. per square inch, to which latter pressure the safety valve was screwed down.

The draught of the engine was created by the escape steam passing into, and from, a tubed exhaust box,—no other draft was used while running; at the water stations "Reilly's patent fan" was used when fresh coal was thrown on the fire, but at no other time.

The speed of the train was noted when passing through some curves of 819 feet radius on the 9 mile level, and found to be 9.8 miles per hour: on a straight line on the same level the engine attained a speed of 10.5 miles per hour.

So little was the engine affected by her performance on the 20th, that on the 23d she drew, on her return trip, 88 burden cars, 9 of which were loaded, and a locomotive engine, making a gross weight of 163 tons of 2 240 lbs., not including engine or tender, up a grade of 18.4 feet per mile. The train had a strong head wind against it during the whole trip, which, owing to its length, 1 206 feet, was sensibly felt at some exposed points of the road, and must have proportionably affected the power of the engine.

WEIGHT AND DIMENSIONS OF THE ENGINE "GOWAN AND MARX."

Weight when empty 21 640 lbs. In running order, with fuel and water, 24 660 lbs., on four driving wheels in running order, or with water, fuel, and two men, 18 260 lbs. Cylinders 12", by 16 inch stroke: 8 wheels, 4 of which are driving wheels, coupled, 3 feet 4 inches diameter; truck wheels 2 feet 6 inches diameter.

The weight of the burden cars averaged from 1.5 to 1.65 tons, of 2 240 lbs. each; they were all 4 wheeled—wheels 3 feet diameter, and 4 feet 6 inches apart from centre to centre.

The above performance, of an 11 ton engine, is believed to exceed any on record in this or any other country."

From the remarks made by Mr. MILNOR ROBERTS at the time of the presentation to the Society of the original drawings of works on the Reading Railroad:

In regard to the locomotive "Gowan and Marx," to which Mr. Robinson refers in his letter, and upon the performance of which Mr. Nicolls, at that time Superintendent of Transportation on the Reading Railroad, made his report in February, 1840, allow me to mention briefly some of the principal features of the road, the engine and its performance.

I recollect very well the sensation it created at the time both in this country and in Europe, as showing a material advance in loco-

motive construction. Previously, most of our locomotives had but two driving wheels, and their normal power of hauling was very much less than that exhibited by the Gowan and Marx.

The Reading Railroad had been very carefully and judiciously located by Mr. Robinson, its Chief Engineer, so as to present only descending or level grades from the coal region to Philadelphia, in the Schuylkill valley. There is one level of nine miles. The aggregate of the levels between Reading and Philadelphia is 27 miles, being about half of the distance. The residue has grades not exceeding 19 feet per mile; the whole distance, 54½ miles, averaging 3.94 feet per mile.

The real test was upon the 9 mile level, where the engine pulled the train through some curves of 819 feet radius at the rate of 9.8 miles per hour; and on a straight line of 10.5 miles per hour.

The train consisted of 101 four-wheeled cars, which weighed 154½ tons, of 2 240 lbs. (average weight of single car, 1.53 tons). The freight weighed 268½ tons, of 2 240 lbs. (average load per car, 2.66 tons). Total weight of train, exclusive of engine and tender, 423 tons of 2 240 lbs.; being about 39 times the weight of the locomotive, which was 11 tons.

The weight of the locomotive, when empty, 21 640 lbs. In running order, with fuel and water, 24 660 lbs. Weight on the four drivers, in running order, with water, fuel and two men, 18 260 lbs.

Cylinders 12⅝ inches by 16 inch stroke; 8 wheels, four of which were driving wheels, coupled, 3 feet 4 inches diameter; truck wheels, 2½ feet diameter.

The 4 wheeled cars had wheels 3 feet diameter, 4 feet 6 inches apart, from centre to centre.

Track laid with T rail, 45 lbs. per yard; gauge 4 feet 8½ inches.

The engine started the whole train on a level.

The steam ranged from 80 lbs. to 130 lbs. The draft of the fire was created by the escape steam passing into and from a tubed exhaust box. "Reilly's patent fan" was used when fresh coal was thrown on the fire, but at no other time.

The concluding remark of Mr. Nicolls report is, "The above performance of an 11 ton engine, is believed to exceed any on record in this or any other country." The date of this performance was February 24, 1840; almost 38 years ago.

Many changes, and numerous improvements have been made during these 38 years, in the construction and use of American railroads, locomotives and cars; and the capital invested in some of our most important roads, is, in some cases, ten, fifteen, and even twenty times more than it was originally. The business also has been immensely augmented: though not proportionally with the augmented capital. The weight of the rail has been increased about 50 per cent., the weight of the empty car, upon 4 wheels, instead of being only 3 360 lbs., is at least two and a-half times as much, or, say 8 400 lbs., while the freight now carried is little more than the weight of the car, whilst in 1840, the car carried one and three-fourths times its weight. At the present day, if the passenger cars and sleepers, and cattle cars are taken into the account, the roads actually carry little, if any, more than the weight of the cars.

Locomotives weighing four times as much as the Gowan and Marx. cannot pull four times the amount of gross load pulled by that engine; much less can they transport four times her net load of freight.

Allowing 8 tons (of 2 240 lbs.) for the weight of a car, and 10 tons (of 2 240 lbs.) for the load of each car, it would require 212 cars, weighing 1 696 tons, to carry 2 120 tons of load; the total weight being 3 816 tons.

The performance of a 44 ton engine of the present day, might possibly be about half of this.

That is, if it be assumed that an engine might now pull a gross weight of 1 908 tons, it would convey but 848 tons of freight: or 4½ times the gross weight of the Gowan and Marx train, could show only 3½ times the freight that was carried on that train.

A battle has been raging for some years between armor plates on one side, and penetrating projectiles on the other; and the question may be asked, whether there is not another engineering battle now going on, between the weight and material of the rails, to withstand, and the weight and power of the locomotives and trains to destroy. In both cases, large sums are needed to carry out the experiments. It is a question, whether in the grandeur of certain things, we may not have passed the economical point.

An occasional reference to the railroad experience of forty years ago, may serve to show that some practical mechanical knowledge then existed, and that it was applied with good results.

I can state as within my own experience in the Alleghany Portage Railroad, Pennsylvania, in 1834, that there were performances of locomotives built by Wm. Norris, of Philadelphia,

in running over smooth rails up inclines of over 500 feet per mile; and one of his engines at one time conveyed a passenger car, with 50 passengers in it, up an incline of 422 feet per mile, at the rate of ten miles per hour.

THE FOLLOWING LETTER has been received from the *Verein Deutscher Ingenieure* (Society of German Engineers) :

To the American Society of Civil Engineers :

In the expectation that many of the American engineers who may visit the Exposition at Paris, will feel an interest in the industries of Germany, which, as is known, will not be represented in Paris, and thinking that they may desire on this occasion to visit the factories and works of Germany, the *Verein Deutscher Ingenieure* remembering most gratefully the very kind and hospitable reception enjoyed by German engineers at the time of the Exposition at Philadelphia, offers most heartily a cordial welcome to its American colleagues, and desires to render all possible service to them.

We have therefore the honor, in the name of the Verein, to invite the members of the American Society of Civil Engineers or such other American Engineers as may be introduced by the Society, to visit the various industrial districts of Germany, and we add herewith a list of persons who have themselves offered to assist by information and introductions, such visitors from the United States as may apply to them.

With high esteem, in the name of the *Verein Deutscher Ingenieure*,

FR. EULER,
President,
Director of the Iron Works,
Kaiserlauten.
Prof. Dr. F. GRASHOF,
Director, Carlsruhe.

1. AACHEN DISTRICT.

Director Bilharz in Preussisch Moresnet bei Aachen.
Kesselfabrikant G. Piedboeuf, Professor G. Herrmann, Professor Dr. Dürre, Generaldirector Landsberg, in Aachen.
Generaldirector Hupperts, Mechernich.

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C. Erdmann, Director der Duisburger Maschinenbau-Actiengesellschaft in Duisburg.
A. Thielen und A. Coupette, Directoren der Actiengesellschaft Phoenix zu Saar bei Ruhrort.
C. Lueg, Director der Actiengesellschaft Gutehoffnungshütte in Oberhausen.
H. Jacobi, Director der Actiengesellschaft Gutehoffnungshütte in Herkrade.
Schlink, Director der Friedrich-Wilhelms-Hütte in Mulheim a. d. Ruhr.

3. WUPPERTHAL, REMSCHEID, SOLINGEN.

Der Vorstand des Bergischen Bezirksvereins (Vorsitzender : Ingenieur Korse in Barmen).

4. OTHER DISTRICTS OF WESTPHALIA.

Ingenieur W. Brügmann, Civilingenieur F. Peters, Dortmund.
Civilingenieur Schemeltzer, Hagen.
Disselhof, Dirigent des Wasserwerks in Iserlohn.

5. SIEGEN DISTRICT.

Civilingenieur Macco, Siegen. Director Jasper, Creuzthal. Ingenieur Wintersbach, Dahlbruch.

6. CASSEL DISTRICT.

Geh. Commerzienrath O. Henschel. (Maschinerfabrik von Henschel & Sohn), Cassel.
Kgl. Ober-Maschenenmeister Th. Büte, Cassel.

7. HANNOVER DISTRICT.

Maschinenfabrikant A. Knörenagel, Geh. Rath Professor Dr. Rühlmann, Professor F. Fisher, Berg-Ingenieur H. Reck, Hannover.

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P. Baumann, firma : Baumann & Magnet. Zuckerfabrik in Buckau.
Bergmeister Lehmer, Ingenieur W. Rothe, Bernburg.
Fabrikbesitzer Mook, Leopoldshall bei Stassfurt.
Ingenieur Gotth, Sachsenber, Rosslau a, d. Elbe.

9. BERLIN AND VICINITY.

Geh. Rath Professor Reuleaux. Geh. Oberbaurath Schönfelder, Geh. Bergrath Dr. Wedding. Berlin.
Salinendirector Mosler, Schönebeck.

10. STETTIN DISTRICT.

Regierungs und Baurath Dresel. Schiffbau-Director F. Haack, Fabrikeninspector Hertel, Stadtrath Koppen, Ober-Maschinenmeister Truhlsen.

11. SILESIA.

Civilingenieur Richn, Görlitz. Obergrath Althaus, Breslau. Kgl. Bergwerksdirector Koch, Tarnowitz. Bergrath Broja, Zabrze.
Hüttendirector Schrackell, Civilingenieur Nack, Bergassessor Lucke, Kattowitz.

12. BAVARIA.

G. Krauss, Chef. der Locomotivfabrik Krause & Cie, München.
C. Linde, Professor am Polytechnicum, München.

Zemann, Redacteur von Dingler's Polytechnichem Journal, Augsburg.

A. Frommel, Gerant der Spinnerei und Weberei, Augsburg.

G. Ultsch. Professor der Kgl. Industrieschule, Nürnberg.

Hilpert. Director der Machinenbau-Gesellschaft. Nuremberg.

Professor Dr. von Wagner, Würzburg.

Noll, Director der Waggonfabrik, Würzburg.

13. Baden.

Professor Dr. Meidinger. Vorstand der Landesgewerbehälle in Carlsruhe.

14. Palatinate—Saarbrücken,

Dingler, Machenenfabrikant in Zweibrücken.

Ingenieur Kauffer, firma : Eisenwerk Kaiserslauten, Kaiserslauten.

Hans Schon. firma : Kamgarnspinnerei. Kaiserslauten.

Marzall, Eisenbahnwerkmeister, Korn, Lederfabrikant, Saarbrücken.

Ingenieur Brandt, firma : Dingler, Karcher & Cie., in St. Johann.

Bergrath Hoernecke, Dudweiler.

Burbache Hütte, bei Saarbrücken.

Dillinger Hüttenwerke, Saarlouis.

15. Middle Rhine.

C. Heberle, Director der Grube Friedrichssegen bei Oberlahnstein.

Meinecke, Chemiker in Oberlahnstein.

Herzog, Betriebsingenieur der Krupp'schen Hüttenverwaltung in Sayn.

16. Lower Rhine.

Bergassessor von Velsen, Bonn.

Sachs, Director der Gesellschaft Humboldt in Kalk bei Cöln.

Ingenieur C. J. Langen, Cöln.

Hegener. Director der städtischen Gas und Wasserwerke in Cöln.

Frabrikbesitzer Dr. Grüneberg (Chemische Fabrik), Cöln.

Amendment to By-Laws.

Mr. F. Collingwood has proposed for the consideration of the Society the following amendment to the By-Laws, and on his motion, seconded by Mr. Wilson Crosby, it has been directed to be printed and issued with the announcement that it would be regularly moved at the approaching Tenth Annual Convention :

An Amendment to the By-Laws, to take the place of Section 31, adopted at the Ninth Annual Convention, April 25th, 1877.

Section .... Any member entitled to vote for officers of the Society may, before the third Wednesday of September in any year, nominate such officers for the ensuing year, by presenting the names of such nominees in writing, over his own signature, in a sealed envelope, addressed to the Board of Direction, and endorsed, "Nominations for officers."

The Board of Direction or those of its members present at a meeting of the Board, to be held on said third Wednesday of September, for this purpose, shall prepare a list in alphabetical order, under the title of each office, of all the persons thus nominated and eligible to the respective offices, together with the class of membership of each as to whether resident or non-resident.

Within one week thereafter, the Secretary shall mail such list, with a copy of this section, to all members of whatever class.

Members qualified to vote for officers may do so by striking from or adding to this list, and return the same as their ballots, but each ballot shall contain not more than one name for President, one for Secretary, one for Treasurer and one for Librarian, two names for Vice-President and five names for Directors. Of these, one Vice-President, the Secretary, the Treasurer, the Librarian and three Directors must be resident members.

The vote shall be by letter, in like manner as prescribed for admission to membership, and be canvassed at the Annual Meeting next succeeding said third Wednesday in September.

The presiding officer shall appoint three or more tellers for the canvass, who shall reject all ballots not in conformity with the Constitution and By-Laws, and report the result in full to the meeting in writing, such report to be preserved by the Secretary for reference.

The nominee for any office receiving the greatest number of legal ballots shall be declared elected to that office.

If, in any case, in consequence of two or more nominees receiving an equal number of votes, there is no election of a particular officer, the members present, who are entitled to vote, shall elect such officer by plurality ballot, from these nominees receiving the highest number of votes.

A ballot entirely in writing shall not be rejected for that reason.

Mr. Edward P. North has proposed for the consideration of the Society the following amendment to the Constitution, and on his motion, seconded by Mr. M. N. Forney, it has been directed to be printed and issued with the announcement that it would be offered at the approaching Tenth Annual Convention:

Amendment to Constitution.—To amend Article V. as far as relates to the election of a Secretary, as follows :

Hereafter the Secretary shall be appointed by the Board of Direction, and hold his office during their pleasure.

This amendment shall take effect on its passage, and its provisions shall apply to the Secretary elected in November next.

LIST OF NEW BOOKS ON

ENGINEERING AND TECHNOLOGY.

Alphabets: a Monogram and —— Album. New York. New ed. 8vo. *Sabin.* $5.40.

Archæology. Lake Dwellings of Switzerland and other parts of Europe. F. Keller. New York. 2 vols. 8vo. illus. Plates. *Scribner, Welford & Armstrong.* $21.00.

Architecture; Handy book of Villa ——. C. Wickes. London. 4to, illus. Plates. *Crosby, Lockwood & Co.* 42s.

——. Old homes made new, being a collection of Plans, exterior and interior views, illustrating the alteration and remodelling of several suburban residences, with explanatory text. W. Woollett. New York. Folio, illus. *Bicknell.* $1.50.

Art: Essay on Decorative. Geo. B. Warren, Jr. Troy. 8vo. *W. H. Young.* $0.25.

Atlantic, The: An Account of the General Results of the Voyage during the year 1873 and the early part of the year 1876. Sir C. Wyville Thomson, F. R. S. With a Portrait of the author, many colored Maps. Temperature Charts, and Illustrations. New York. 8vo. *Harpers.* $12.00.

Botany; Structural and Physiological ——. Otto W. Thorne, Professor of Botany at the School of Science and Art at Cologne. Trans. and ed. by A. W. Bennett, of St. Thomas' Hospital. 600 Woodcuts and colored Map. New York. Small 8vo. 2d ed. *Wiley & Sons.* $2.25.

Brakes; Continuous Railway ——. A Letter to the Right Hon. Sir Charles Adderley, President of the Board of Trade. By a frequent Railway Traveler. London. 8vo. *Trubner.* 6d.

Bridges; Practical Treatise on the Construction of Iron Highway ——. For the use of Town Committees; together with a short Essay upon the application of the principles of the Lever to a ready analysis of the strains upon the more customary forms of Beams and Trusses. With many fine Engravings. A. P. Boller, A. M., C. E. New York. 1 vol. 8vo, cloth. 2d ed. *Wiley & Sons.* $2.50.

Carriage Builders' Reference Book. With Illustrations and Descriptions of Centennial Exhibits. I. D. Ware. Philadelphia. 8vo, illus.

Catalogue; a general —— of choice books for the library; comprising a selection of the best books by ancient and modern authors, in all departments of Literature, science, and art. Classified and priced. Cincinnati. 12mo. *Clarke.* $0.25.

Chairman's Handbook. 3d ed. Reginald F. D. Palgrave, Clerk-Assist. of the House of Commons. London. *Knight & Co.* 1s. 6d.

Chemistry, Industrial ——. A Manual for Technical Schools, Chemists and Manufacturers. Based upon a translation (partly by Dr. T. Barry) of Stohmann & Engler's German edition of Payens Precis de Chemie Industrielle. Edited throughout and augmented by B. H. Paul, Ph. D. Illustrated by 698 Engravings and containing nearly 1000 pages. New York. 8vo. *Wiley & Sons.* $10.00.

Corporations. The New York Act for the Formation of —— for Manufacturing, Mining, Mechanical, and other purposes. With all the Amendments. Notes, Forms, and Index. Compiled by a member of the New York Bar. New York. 12mo. *Baker, Voorhis & Co.* $0.50.

Design; a Primer of ——. Charles A. Barry, Supervisor of Drawing, Public Schools, Boston. *Lee & Shepard.* (Announcement)

Drainage House —— and water service in cities, villages, and rural neighborhoods. With incidental consideration of causes affecting the healthfulness of dwellings. Jas, C, Bayles. New York. 8vo. *D. Williams.* $3.00.

Drawing. An Elementary Course of Geometrical ——; containing Problems on the Right Line and Circle, Conic Section and other Curves, the Projection, Section, and Intersection of Solids, the Development of Surfaces, and Isometric Perspectives. With 38 Plates, 16 by 20. George L. Vose. Boston. *Lee & Shepard.* (Announcement.)

—— Elements of Machine Construction, or Machine Drawing, with some Elements of descriptive and rational cinematics. A text book for schools of Civil and Mechanical Engineering and for the use of Mechanical Establishments, Artisans and Inventors—containing the principles of Gearing, Screw Propellers, Valve Motions, and Governors, and many standard and novel examples, mostly from present American practice. S. Edward Warren, late Professor in the Rensselaer Polytechnic Institute. New York. 2 vols. 8vo, illus. plates. *Wiley & Sons.* $7.50.

—— Industrial—comprising the Description and uses of Drawing Instruments, the construction of Plane figures, the Projections and sections of Geometrical Solids, Architectural Elements, Mechanism and Topographical Drawing, for the use of academies and common schools. By Prof. D. H. Mahan. Revised and enlarged and chapter on colored topography added by Prof. D. F. Thompson of Troy. New York. 8vo, 30 plates. *Wiley & Sons.* $5.50.

Dynamics. Elements of——: Mechanics. With numerous Examples and Examination Questions. J. Blaikie. Edinburgh. Post 8vo. *Simpkin, London.* 3s. 6d.

Engineering. Aid book to —— enterprise abroad. Ewing Matheson. London. 8vo. *Spons.* 12s. 6d.

Engineers. Proceedings of the Association of Municipal and Sanitary —— and Surveyors. Edited by L. Angel. London. Vol. 3. 8vo. *Spons.* 10s. 6d.

Explosives. Guide book to the —— Act, 1875. For the use of local authorities and their officers. By Major Majendie, R. A., H. M. Inspector of Explosives. By authority. Bound in leather, 320 pages London. *Knight & Co.* 2s.

Graphical Statics. Elements of —— and their application to Framed Structures. With numerous practical Examples: Cranes, Bridge, Roof and Suspension Trusses; Braced and Stone Arches; Pivot and Draw Spans; Continuous Girders, etc; together with the best methods of calculation, and containing also new and practical formulæ for the Pivot or Draw -span, Braced Arch, Continuous Girder, &c. 2 volumes, 8 vo; 1 vol. text and 1 vol. plates—2d ed. Prof. A. Jay DuBois, Professor of Engineering in Sheffield Scientific School—late Professor at Lehigh University. New York. *Wiley & Sons.* $5.00.

Guide. The Pacific tourist, illustrated transcontinental —— of travel from the Atlantic to the Pacific Ocean. 1878. New York. 4to. *H. T. Williams.* $1.50.

Iron and Steel. The calculations of strength and dimensions of iron and steel constructions; with reference to the latest experiments. By Prof. J. J. Weyrauch, of Polytechnic Institute of Stuttgart. Translated by Prof. H. Jay DuBois. The only authorized translation. In 1 vol. New York. 8vo, plates. *Wiley & Sons.* $1.50.

Indian Population—How shall we treat the red man? Lieut. E. O. Otis, U. S. Army. New York. 12mo. *Sheldon.* $1.50.

Irrigation. Facts and Fallacies regarding —— as a Prevention of Famine in India. John Dacosta. London. 8vo. *W. H. Allen.* 6d.

Mechanics. Principles of Elementary —— designed to give more attention to the fundamental principles of mechanics. De-Volson Wood, Prof. of Mathematics and Mechanics in Stevens Institute. New York. 12mo, illus., cloth, 150 pp. Wiley & Sons. $2.00.

Military Engineering. Instructions in — —. Vol. I, part 4, Military Mining, compiled at the School of Military Engineering, Chatham. 2d ed. Post 8vo. British Government Publication. 1s. 6d.

Mineralogy, A Text-Book of ——, Based upon the System of Mineralogy by J. D. Dana. Embracing an extended treatise on Crystallography and Physical Mineralogy. By E. S. Dana, Curator of Mineralogy, Yale College. With upwards of 800 woodcuts, and one colored plate. New York. 8vo, cloth. 2d Ed. *Wiley & Sons.* $5.00.

———, A Manual of Determinative —— and Blow Pipe Analysis, by George Jarvis Brush, of Sheffield Scientific School. New York. 8vo. 2d Ed. *Wiley & Sons.* $3.00.

———, A new revision of the above, with New Notation, conforming with Dana's Text Book on Mineralogy. *Wiley & Sons.* (Announcement.)

Modern Countries, Resources of —— ——. Alex. J. Wilson. 2 vols. 8vo. *Scribner, Welford & Armstrong.* $12.00

Navy, Records of Living Officers of the United States —— and Marine Corps. Comp. from official sources. Lewis R. Hamersly. Philadelphia. 3d ed. rev. 8vo. *Lippincott.* $5.00.

———, The Gun, Ram, and Torpedo; or, Manœuvres and Tactics of a Naval Battle of the Present Day. By Com. Gerard Noel, R. N., the Royal Yacht. London. Crown, 8vo, illus. *Simpkin.* 8s. 6d.

Painting. Studio, Field and Gallery, A Manual of ——, for the Student and Amateur, with information for the general reader. Horace J. Rollin. New York. 12mo. *Appleton.* $1.50.

Pennsylvania Rail Road. History of the —— —— ——. Republished from the London Engineering. 220 pp. of text, 60 illustrations, more than 100 tables. 79 plates, including about 25 double page plates. 1 vol. folio, 450 pp. Half morocco. Sold by subscription. *Wiley & Sons.* Previous to issue, $15.00: after issue, $20 00.

Perspective, Second Grade —— (Theory and Practice). Specially prepared for the use of Art Students. H. J. Dennis. London. 4to. *Bailliere.* 2s. 6d.

Pocket Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers, with a valuable contribution on Telegraphs by R. S. Brough and Paget Higgs. G. L. Molesworth. London. 32mo. 19th Ed. *Spons.* 6s.

Railway Manual, Bradshaw's —— ——, Shareholder's Guide, and Official Directory for 1878. London. Post 8vo. *W. J. Adams.* 12s.

Sanitary Engineering. Wholesome Houses: Being an Exposition of the Banner System of Sanitation. 25th ed. Ed. G. Banner. London. 12mo. illus, *Crosby, Lockwood & Co.* 1s.

—— ——. Practical Information as to the Law relating to the Removal of Nuisances and Public Health. London. *Knight & Co.* 1s.

Science Lectures at South Kensington, Vol. I. By Capt. Abney, R.E., F.R.S.; Professor Stokes, Professor Alexander B. W. Kennedy, C.E.; F. J. Bramwell, Esq., C.E., F.R.S.; Professor F. Forbes, H. C. Sorby, F.R.S., J. T. Bottomley, M.A., F.R.S.; Sidney H. Vines, B.A., B.Sc.; Professor Carey Foster. New York. 12mo. *Macmillan.* $1.75.

Sea Terms, French —— —— and Phrases. By Lieut. Pornain, French Navy. London. 8vo. *Simpkin* 4s.

Steam Engine. The Theory of the —— —— Trans. from the 4th ed. of Weisbach's Mechanics, by Prof. A. Jay DuBois. With an Appendix of Practical Examples of Stationary, Marine and Locomotive Engines, showing American practice, by R. H. Buel. New York. 8vo, illus. *Wiley & Sons.* $6.00.

—— —— Simple and Compound Engines. Their Relative Merits, by Niel Macdougall, Esq., Admiralty, London. Second Edit., demy 8vo, ills. 3s. 6d.

Statistical Tables. Hubner's Universal —— —— containing Area in square miles: Forms of Government: Head of ditto; Population; Expenditure; National Debt; Paper Money; Notes in Circulation; Standing Army; Navy; Merchant Vessels; Imports; Exports; Chief Native Produce; Money, Weights, and Measures; Chief Towns and Seaports; Population of Cities of all Countries in the World. 1 sheet imperial. London. *Trubner.* 1s. 9d.

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sives, Principles of Blasting, and Descriptions and Use of the various Rock Drills and Compressors, together with American and Foreign Systems of Arching, and Tables showing Cost and Dimensions of over 1700 Tunnels from every part of the world, and Profiles, Maps, and over 1000 illustrations, by Henry S. Drinker, Mining and Civil Engineer. New York. 4to. *Wiley & Sons.* Sold only by subscription. Price, previous to issue, $15.00 ; subsequent to issue, $20.00.

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Water Supply of Cities and Towns. A Comprehensive Treatise on the ——— ——— ——— ——— ——— ——— With numerous specifications of existing water works. William Humber. London. 1st American edition, 4to, illus., and 50 double plates. *Geo. H. Frost* (*Engineering News*) *Chicago.* Issued in 12 parts. For each part, $1.25 ; for 12 parts, $10.00.

ADDITIONS TO

LIBRARY AND MUSEUM.

From Administration dès Ponts et Chaussèes, Paris :

Annales dès Ponts et Chaussées, March, 1878.

From Argentine Scientific Society, Buenos Ayres:

Annals of the Society, February and March, 1878.

From Austrian Society of Engineers and Architects, Vienna:

Transactions of the Society, Parts 3 and 4, 1878.

From Theodore Belpaire, Paris:

Tables permettant d'effectuer rapidement les calculs relatifs à la stabilité des voûtes. Theodore Belpaire, Paris.

Essai d'une Théorie des Voutes en berceau, en arc de cercle et en plein centre. Theo. Belpaire, Paris.

From Boston Public Library:

The Bulletin of the Library, No. 45. April, 1878.

From the Buffalo Board of Water Commissioners:

Ninth Annual Report of the Buffalo City Water Works for 1877. Buffalo.

From the Engineers' Club of Philadelphia:

Report of the Committee of the Club on the Metric System of Weights and Measures. Philadelphia, 1878.

From the Hanover Society of Engineers and Architects:

Transactions of the Society, Part 2, 1878. Hanover, 1878.

From D. Farrand Henry, Detroit, Michigan:

The 26th Annual Report of the Board of Water Commissioners. Detroit. (3 copies.)

From A. L. Holley, New York:

The Strength of wrought iron as effected by its composition and by its reduction in rolling. Philadelphia, 1878. (10 copies.)

From the Imperial Russian Polytechnic Society:

Proceedings and Transactions of the Society. Vol. I., 1878. St. Petersburgh.

From the Institution of Civil Engineers:

Minutes of Proceedings of the Society. Vol. LI. Session 1877-78, Part 1. London.

From John B. Jervis, Rome, N. Y.:

The Future of the Erie Canal. John B. Jervis. 1878.

From the Ministry of Public Works, Paris, France:

Year Book of Public Works for year 1878. Paris.

From E. P. North, New York:

Salisbury iron, its composition, qualities, and uses. Salisbury, Conn.

General Powder and Electric Blasting Apparatus. May, 1878. Latlin & Rand Powder Co., New York:

From the North of England Institute of Mechanical and Mining Engineers:

Transactions of the Society, November and December, 1877. Newcastle-upon-Tyne, 1878.

From Charles Paine, Cleveland, Ohio:

Eighth Annual Report of the President and Directors of the Lake Shore and Michigan Southern Railway. 1877. Cleveland, 1878.

From Ernest Pontzen, Paris, France:

Etude sur l'Exploitation des Chemins de fer par l'Etat. M. F. Jacquien, Paris.

Der Lupkower Tunnel der Ersten ungarisch galizischen Eisenbahn. Rudolph R. V. Gutmesch. Vienna.

From Levi W. Post, Jersey City:

Annual Report of the Chief Engineer of the Board of Public Works of Jersey City. December 31, 1877. New York, 1878. (10 copies.)

From the Railroad and Warehouse Commission of Illinois:

Seventh Annual Report. Springfield, Ill.

From Hon. Saml. J. Randall:

Congressional Record, 45th Congress, 2d Session. April 21st, 1878. Washington.

From I. W. Smith, Sacramento, Cal.:

Report of the Board of Transportation Commissioners to the Legislature of California, December, 1877.

Explanation of Tables, &c., Supplementary Report of Board of Transportation Commissioners of California, January 14th, 1878.

Blanks for years 1876 and 1877 for reports of railroads to Board of Transportation Commissioners of California.

Legislative Acts in relation to Railroads of California. 1878.

From J. Herbert Shedd, Boston:

Report in relation to Sewerage of the City of Lynn, and a report of the Committee on Drainage. J. Herbert Shedd. Lynn. 1877.

From the Saxon Society of Engineers and Architects, Leipsic:

Transactions of the Society. 1877.

From the Technical and Administrative Military Committee, Vienna:

Communications upon Artillery and Engineering Operations. 2d part. 1878.

From the Treasury Department, Washington:

Annual Report of the Light House Board to the Secretary of the Treasury. 1877.

From R. H. Thurston, Hoboken, N. J.:

Thermal and Mechanical Properties of Air shown by lithographed curves due to changes of temperature, pressure and volume. R. H. Thurston. 1877.

Abstract of Statement of the extent and character of the work of the United States Board appointed to test Iron, Steel, and other Metals. R. H. Thurston. Salem, Mass.

On a new method of planning researches, and of representing to the eye the results of combination of three or more elements in varying proportions. R. H. Thurston. Salem, Mass.

The Growth of the Steam Engine. R. H. Thurston, New York, 1878.

From S Whipple, Albany, N. Y.:

An investigation as to the mode and amount of attraction between large and small bodies in contact or at small distances. S. Whipple. Albany, N. Y., 1877. (several copies.)

From H. M. Wightman, Boston:

Annual Report of the City Engineer of Boston for the year 1877.

From W. W. Wilson, Yonkers, N. Y.:

Fifth Annual Report of the Board of Water Commissioners of the City of Yonkers. 1877.

From David Williams, New York:

The Metallurgical Review. Vol. I.

From A. F. Wrotnowski, New Orleans, La.:

Report of the Board of State Engineers of Louisiana for the year 1876. New Orleans, 1878.

ANNOUNCEMENTS.

THE TENTH ANNUAL CONVENTION of the Society will be held at Boston, beginning Tuesday, June 18th, 1878.

Sessions for the consideration of professional subjects, and one for the transaction of business will be held.

The meetings of the Convention will be held in the Hall of the Massachusetts Institute of Technology, on Boylston street, which has been kindly placed at the disposal of the Society for this purpose.

The first session of the Convention will be at 10 A. M., Tuesday, June 18th, and for that and the following days the following general programme is proposed:

TUESDAY, JUNE 18TH.—Sessions at 10 A. M., and at 7½ P. M. During the afternoon, by invitation of the Boston Society of Civil Engineers, an excursion will be made by rail to Newton Upper Falls (Aqueduct Bridge, Boston Water Works), thence returning to the city *via* the Chestnut Hill Reservoir and suburbs of Boston.

WEDNESDAY, JUNE 19TH.—Sessions at 10 A. M., and at 7½ P. M. Such portion of the evening session as may be determined upon to be for the transaction of business. During the afternoon several excursions to places of interest about the City of Boston will be made. Each of these excursions will be in charge of a member of the Local Committee, and visitors will elect which one to join.

THURSDAY, JUNE 20TH.—By invitation of the Boston Board of Trade, an examination of the upper harbor of Boston and its improvements, and an excursion down the harbor. Convention dinner in the evening, at the Hotel Brunswick.

FRIDAY, JUNE 21ST.—By train to Lowell, and examination of the works of interest there. Thence to Lawrence, and, after visiting that City, return to Boston.

By invitation of Gen. A. P. Rockwell, President of the Eastern Railroad, an excursion will be made over that road to North Conway, and thence by the Portland & Ogdensburg Railroad to the Incline at Mount Washington.

The following is a list of topics to be considered with reference to papers published in Transactions during the preceeding year:

BRIDGES.

CXL. Approximate determination of stresses in the Eye-Bar Head. WILLIAM H. BURR.

CXLIV and CXLIX. Relative quantities of material in bridges of different kinds, of various heights. CHARLES E. EMERY.

CXLVII. Proportion of Eye-Bar Heads and Pins as determined by experiment. C. SHALER SMITH.

CLVI. A new method of detecting overstrain in iron and other metals, and its application in the investigation of the causes of accidents to bridges and other constructions. ROBERT H. THURSTON.

BOILERS.

CXLI. Connected-Arc Marine Boilers, a demonstration of the principles of their construction. CHARLES E. EMERY.

—— Discussion on above paper. J. FOSTER FLAGG. Vol. VI., page 294.

CEMENTS.

CLII. Notes and Experiments on the use and testing of Portland Cement. WILLIAM W. MACLAY.

DAMS.

CXLVIII. Wing Dams in the Mississippi above the Falls of St. Anthony. EDWARD P. NORTH.

HYDRAULICS.

CXXXIX. The Consumption and Waste of Water delivered by Public Works. JAMES H. HARLOW.

CXLV. The flow of water in open channels. THEODORE G. ELLIS.

CLIV. A peculiar case of failure in a water main. D. MCN. STAUFFER.

— Discussion on above paper. Vol. VII, p. 15.

MASONRY.

CLI. Nomenclature of Building stones and stone Masonry. J. JAMES R. CROES, WILLIAM E. MERRILL and EDGAR B. VAN WINKLE.

MINES AND BLASTING.

CXLII. On the simultaneous ignition of thousands of mines and the most advantageous grouping of fuses. JULIUS H. STRIEDINGER.

CLIII. On igniting blasts by means of electricity. JULIUS H. STRIEDINGER.

PRESERVATION OF TIMBER.

—— Discussion on this subject. Vol. VI, page 189.

RAILROADS.

CLVIII. Construction and operation of the Incline Plane Railroad at Madison, Ind. M. J. BECKER.

RIVERS AND HARBORS.

CXLIII. Improvement of Entrance to Galveston Harbor. CHARLES W. HOWELL.

CLV. The Improvement of the South Boston Flats. EDWARD S. PHILBRICK.

—— Discussion on Levees as a system for reclaiming low lands. J. FOSTER FLAGG. Vol. VI, page 305.

STEAM ENGINES.

CLVII. Steam engine economy. A uniform basis for comparison. CHARLES E. EMERY.

SURVEYS.

CXXXVIII. Co-ordinate Surveying. HENRY F. WALLING.

CXLVI. A novel railroad survey. THOMAS S. HARDEE.

CL. Description of survey for determining the slope of water surface in the Erie Canal. WILLIAM H. SEARLES.

In addition to the above papers, it is expected that the following subjects will be presented by papers printed previous to the date of the Convention, or read at its meeting :

Dams across Water Courses. WILLIAM J. MCALPINE.

The rain fall during a storm in October, 1869. JAMES B. FRANCIS.

The law of Tidal Currents. J. H. STRIEDINGER.

The South Pass Jetties ; descriptive and incidental notes and memoranda. E. L. CORTHELL.

Discussion on the preceding paper. CHARLES W. HOWELL.

Reminiscences and experiences of early engineering operations on railroads, with especial reference to steep inclines.

No. 1, W. MILNOR ROBERTS.

No. 2, WILLIAM J. MCALPINE.

Resistances on Railway Curves. S. WHINERY.

Notes on the papers in reference to Incline Planes and Resistances on Railway Curves. —OCTAVE CHANUTE.

Agricultural Drainage. ED. N. KIRK TALCOTT.

A graphic method of representing railroad accounts. CHARLES LATIMER.

Science, old and new. Its relation to Engineering. W. MILNOR ROBERTS.

The Mississippi River.—B. M. HARROD.

Brick Arches for Large Sewers. R. HERING.

Improvement of Galveston Harbor (2d Paper). CHARLES W. HOWELL.

The Flow of Water in Pipes. CHARLES G. DARRACH.

The proper arrangement and ventilation of house drains. CHARLES E. FOWLER.

On a newly discovered relation between the tenacity of metals and their resistance to torsion. R. H. THURSTON.

On Gauging Streams. CLEMENS HERSCHEL.

Members of the Society are earnestly requested to furnish information or memoranda upon any of the subjects referred to. They are also invited and expected to take part in the discussions either in person or by sending to the Secretary notes for presentation.

In either case, it will assist the Committee in arranging the details for sessions of the Convention, if Members expecting to take part in the discussions will notify the Secretary at once to that effect.

Reports will be expected, as follows :

From Committees on Gauging of Streams, J. James R. Croes, Chairman ; Permanent Quarters for the Society, John Bogart, Chairman ; Resistances of Railway Trains, William P. Shinn, Chairman : Uniform Accounts and Returns of Railroad Companies, William P.

Shinn, Chairman; Tests of American Iron and Steel, W. Sooy Smith, Chairman; On Exhibit at the Paris Exposition, Geo. S. Morison, Chairman; The Centennial Commission of the Society, Theodore G. Ellis, Chairman.

Members who intend to be present at the Convention are requested to immediately notify the Secretary to that effect, either upon the blanks already sent out or otherwise.

Transportation for Members has been already secured over many lines, and it is hoped will be obtained over others. Notice of what can be furnished will be sent to Members expecting to visit the Convention.

The Boston Society of Civil Engineers; the Engineers' Club of the Northwest, of Chicago; the Engineers' Club of St. Louis; the Engineers' Club of Philadelphia, and the New Haven Engineering Society, have been invited to attend the Convention. The Local Committee has made arrangements for Members at reduced rates ($3.50 per day) at the Hotel Brunswick, on Boylston street, which is opposite the place of meeting of the Convention.

Invitation to visit the works of interest at and in the vicinity of Fall river is extended to all visitors to the Convention, by Mr. Wm. Rotch, Chief Engineer of the Fall River Water Works, and Member of the Society. Among these works are an iron bridge for railroad and highway over the Taunton river; the water works of the City, and some of the forty cotton mills, which, together, contain 1 250 000 spindles. These works can be visited either before or after the Convention.

Arrangements have been made for the trip from New York to Boston and return, by Sound steamers, at $3.00 the round trip, not including stateroom. Most of the members purpose leaving New York on Monday evening, June 17th.

Notify the Secretary at once if you desire a berth reserved for you in stateroom.

Discordant Standards of Measurement. —A number of members of the Society desire to obtain for publication, statements of the various discordant standards of measure in use in the United States. It is known that in many cities the old standards are more or less at variance with the present, and that, quite frequently, confusion and annoyance are the result. A table, compiled from the information which is undoubtedly in the possession of members of the Society, would be both interesting and valuable. The request is, therefore, made, that any information which would be of assistance in the preparation of such a table be forwarded to the Secretary. The replies should state the equivalent of the measures referred to in U. S. standard feet or in meters, together with any additional notes which may be applicable. If provisional equivalents, afterwards proving incorrect, have been adopted, the value of these should also be stated.

In the Transactions of the Society of Engineers and Architects of Hanover, Vol. XXIV., No. 2, 1878, there is an abstract of the Paper by John T. Fanning, member of this Society, entitled "A Water Conduit under Pressure," which was published as Paper No. CXXXVI., Transactions, Vol. VI., page 69, March, 1877.

Members of the Society who expect to visit Europe during the present year, are requested to inform the Secretary as soon as possible of that fact, and also of the time when they purpose leaving and the probable length of their stay abroad, together with their European address.

Members who desire to secure complete sets of the Transactions of the Society are requested to send to the Secretary a list of the papers which are needed to fill up their sets. Some of the earlier papers are out of print. If orders are received for a sufficient number to warrant the expense, a reprint will be made.

The following resolution was adopted at the Ninth Annual Convention of the Society and ordered printed regularly in the Society publications:

Whereas, the metric system of weights and measures is now extensively used abroad; and whereas, it is desirable that the relation of the units of differing systems be made familiar to all, by comparison:

Resolved, That Members be requested, in papers hereafter presented to the Society to write, in parenthesis, weights or dimensions by the metric system in connection with those of the system in general use.

The House of the Society is at 104 East Twentieth street, one door east from Fourth avenue, and near southwest corner of Gramercy Park. It is open from nine o'clock A. M. to five o'clock P. M. each business day except Saturday, when it is closed at three o'clock P. M.

The Library and Conversation Rooms will also, for the present, be open every *Thursday evening*, from 7½ to 10 P. M. Members are invited to avail themselves of the opportunities afforded on Thursday evenings both for consultation of books and periodicals and for conversation.

LIST OF MEMBERS.

ADDITIONS.

MEMBERS.

		Date of Election.
FORCE, C. G., JR.	City Civil Engineer's Office, Cleveland, Ohio	Feb. 6, 1878.
GREENE, B. H.	Chief Engineer, New Orleans Pacific Ry., New Orleans, La.	May 1, 1878

CHANGES AND CORRECTIONS.

MEMBERS.

DICKINSON, P. P. ..... 35 Coal and Iron Exchange, New York.
EVANS, WALTON W. ..... 66½ Pine Street, New York.
GREENE, DAVID M. ..... Troy, N. Y.
LANE, MOSES. ..... 1616 Grand Ave., Milwaukee, Wis.
OWEN, JAMES. ..... Civil Engineer, 748 Broad Street, Newark, N. J.

JUNIORS.

MACY, ARTHUR ..... 20 Cedar Street, New York.
RAYMOND, CHARLES W. ..... Dept. of Docks, foot of Barrow Street, New York.

ASSOCIATE.

HARRIS, CHARLES M. ..... (Care Am. Soc. Civil Engs.), New York.

FELLOW.

FLINT, CHARLES R. ..... 87 Wall Street, New York.

RESIGNED.

MILLER, J. IMBRIE ..... Member ..... May 7, 1878.

RECENT PUBLICATIONS.

ARCHITECTURE.—Designs for the Construction of Markets, Warehouses and Sheds. By Alex. Friedmann, C. E. Translated, with an Introduction and Notes, by E. H. D'Avigdor, B.A., C. E. 27 large plates, with explanatory text, in portfolio. $17.00.

CEMENT.—The Science and Art of the Manufacture of Portland Cement; with observations on some of its constructive applications. By Henry Reid, C. E. New edition. Illustrations. 8vo, cloth. $7.00.

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SANITARY ENGINEERING.—A Series of Lectures given before the School of Military Engineering, at Chatham, 1876. By J. Bailey Denton, F.G.S. In one thick volume of 429 pages, royal 8vo, cloth, containing 23 plates, 135 engravings, and many valuable tables. $10.00.

HEAT.—A practical treatise on Heat, as applied to the Useful Arts, for the use of Engineers, Architects, &c. By Thos. Box. Second edition. Plates. 8vo, cloth. $5.00.

HYDRAULICS.—The New Formula for Mean Velocity of Discharge of Rivers and Canals. By W. R. Kutter. Translated from articles in the *Cultur-Ingenieur*, by Lowis D'A. Jackson, A.I.C.E. 8vo, cloth. $5.00.

INDICATOR.—An elementary treatise on Steam and the Use of the Indicator. By J. C. Graham, B. Sc. Illustrations, 8vo, cloth. $3.50.

STEAM JACKET.—The Abuse of the Steam Jacket, practically considered. By W. Fletcher, M.E. Crown 8vo, sewed. $1.20.

MINING MACHINERY.—A descriptive treatise on the Machinery, Tools, and other appliances used in Mining. By Geo. G. André, F.G.S. In two vols., royal 4to, cloth, uniform with the Author's Treatise on Coal Mining. Containing 182 plates, drawn to scale, with descriptive letterpress. Price $28.00. Also in 12 parts, at $2.00 each.

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GAS MANUFACTURE.—A practical treatise on the Manufacture and Distribution of Coal Gas. By Wm. Richards. Numerous wood engravings and large plates. Demy 4to cloth. $12.00.

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CODE OF RULES

FOR THE

AWARD OF THE NORMAN MEDAL.

I. Competition for the Norman Medal of the American Society of Civil Engineers shall be restricted to members of the Society.

II. There shall be one gold medal, and only one, struck for each and every fiscal year of the Society, and awarded as hereinafter provided. The dies therefor shall be with the Superintendent of the United States mint at Philadelphia, in trust exclusively for the aforesaid purpose. Such medal shall be of a cost equal to the annual interest received upon $1 000 of the consolidated stock of the city of New York, certificate No. 179, of additional new Croton Aqueduct stock of the city of New York, authorized by an act of the Legislature of the State of New York, Chap. 230, passed April 15th, 1870, dated November 17th, 1873; now held in trust by the Treasurer of this Society, and so held solely for this purpose; and shall be executed upon his order.

III. The President of the Society, the President of Columbia College, and the Engineer Officer of the United States Army commanding in that capacity in New York city and vicinity, shall be, ex-officio, a Board of Censors, whose duty it shall be to examine all papers entitled to competition under these rules, and award the Norman Medal as a prize of merit, as hereinafter provided.

IV. No papers shall be entitled to competition except such as are of practical engineering interest; it being the expressed intention of the donor to exclude from competition all papers of a purely speculative or theoretical character.

V. Each paper submitted for competition shall be headed with the title, but shall not exhibit the author's name on any part of the manuscript; it shall be accompanied with a sealed envelope, superscribed with the title, and enclosing both the title and the name of the author; the whole to be enclosed in an envelope addressed to "The President of the American Society of Civil Engineers," and conspicuously endorsed "For Norman Medal, year ....." and presented at least two months prior to the Annual Meeting; and no paper otherwise presented, or in possession of the Society, shall be admitted to competition, nor except for the fiscal year in which it shall have been presented.

VI. All papers presented in accordance with the foregoing rule shall first be submitted by the President to the Board of Censors, and after their examination, and at the Annual Meeting, the President shall present the successful essay, together with the sealed envelope containing the author's name, accompanied with the certificate of the Board of Censors, to the Society—when the envelope shall be opened, the author's name announced, and the award declared. Such award shall be entered on the Minutes and published in the proceedings of the Annual Meeting. If for any reason, in any year, there shall be no award of this medal, then the amount of the interest of the fund for that year shall be expended by the Board of Direction in the purchase of books; said books to be offered as a premium for the second best competing paper for the medal of the succeeding year.

VII. The Treasurer of this Society shall cause the medal to be prepared and delivered to, or deposited to the order of the successful competitor, within two months after the Annual Meeting at which the same shall have been awarded.

VIII. The Board of Censors may make such regulations, consistent with this Code, as they may deem proper, and shall have power to fill vacancies in said Board.

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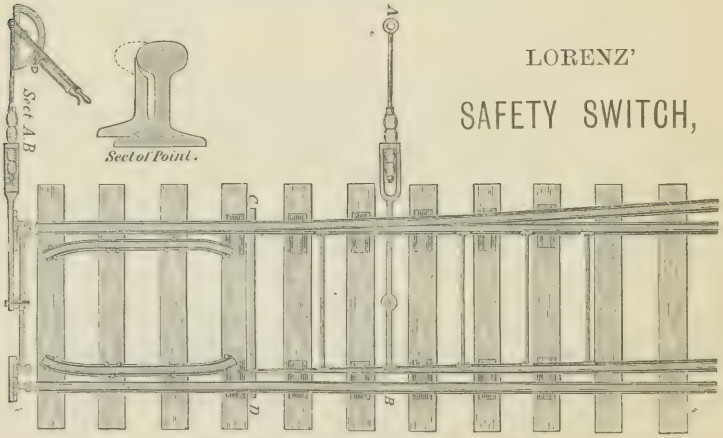

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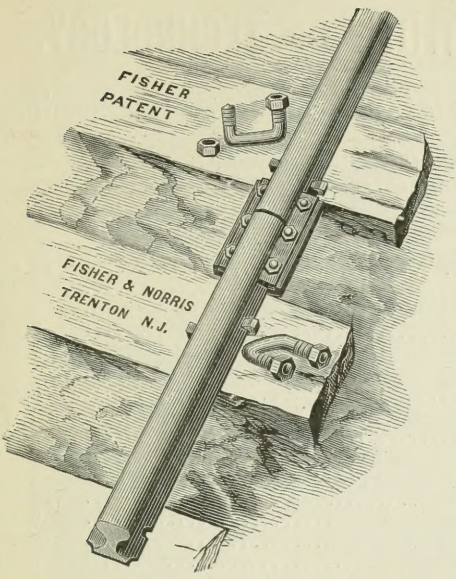

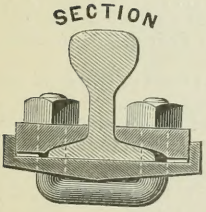

THE "FISHER"

Patent Rail Joint,

MANUFACTURED BY

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In the "Fisher" system by *vertical* bolts, the ends of contiguous rails are securely fastened between heavy horizontal plates, which enclose the flanges.

Of these bolts, usually in pairs in the ⌊⌋ form, one, two, three or four are employed as desired. From their large diameter (one inch), and acting in the same direction as the load, *no loosening of the nuts* occurs, except that due to internal wear of the plates and rail surfaces. Having the whole area of the base of rail, instead of a narrow bearing under the head, as with common fish bars, this wear is very slight, and may be taken directly up by the nuts. Twice a year, using a four foot wrench, is sufficient for this, and no "stop" or other washers are required or used.

Joints taken from the track of the Boston & Providence R. R., after *thirteen years'* continuous use, show this wear to have been $\frac{3}{64}$th of an inch.

No holes are made in the stem of the rail. The only slotting is for elliptical notches in the edges of the flanges and without perceptible weakening of their strength. Several varieties have been in use on important roads, for from four to thirteen years—either between ties, on one tie, or extending the lower plate over two ties, and in every case have demonstrated that for preservation of rails, smoothness of track, and saving in labor and repairs, the *vertical* system, holding the rail by its broad base instead of under the head, directly by large vertical bolts, is the correct one as opposed to fish bars, which are dependent on horizontal bolts to keep them in place—subject to rapid, unequal wear and cross-strains, and with continual loosening of nuts. All fish bars wear greatest at their middle, and after three or four years' use they will be found so much more worn there than at their ends that a perfect bearing can be no longer obtained by screwing up the nuts, and a rapid destruction of the ends of the rails obtains soon after.

Among the roads which have used these joints in large quantities for a number of years, are the Fitchburg R. R., Boston & Providence R. R., Pennsylvania R. R., Lehigh & Susquehanna R. R., Philadelphia, Wilmington & Baltimore R. R., Cumberland & Pennsylvania R. R., Delaware & Hudson Canal Co., &c.

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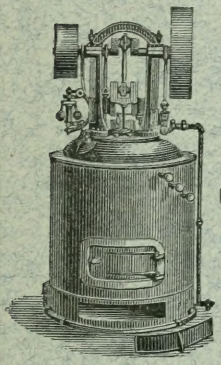

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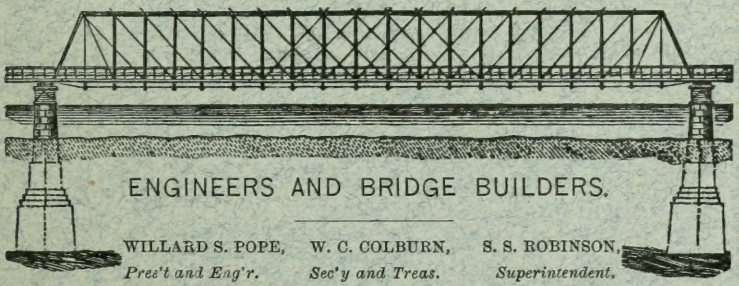

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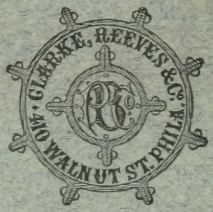

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